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Abstract

Labour demand and wages depend on the state and volatility of relationships within firms. Good relationships lower profit-maximising wages and raise firms' profits and hence constitute an asset to the firm. Wages are lower because when people enjoy collaborating in the absence of wage incentives it is costly to induce them to work even more using such incentives due to rising marginal disutility of effort. Perhaps more surprisingly, volatile relationships among workers who collaborate raise profits and the value of workers in the presence of increasing returns to labour. Such volatility has the effect of raising the profit-maximising wage.

Keywords: Relationships, teams, increasing returns, wages, labour demand.
JEL code: J23, J24, J31, J53

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Two years ago I became head of an economics department. This happened mostly by default as the remaining members of staff were divided into two opposing camps characterised by mutual distrust. The split occurred about ten years ago for reasons that I do not fully understand, except that political views appear to matter as well as views on a host of important social issues. Internal promotions also caused a rift in the department along the same lines. Over the last two years I have had to take the internal division into account in most important decisions. It has also prevented proper delegation of responsibilities, such as the sharing of administrative duties; reduced overall productivity because of there being less collaborative effort; made it very difficult to prevent shirking; and made hiring much more difficult. In my desire to understand and manage such conflicts I have looked for clues in textbooks in labour economics. However, I have been surprised at the apparent lack of importance attached to relationships in the workplace in these books and by how distinct my real life experience is from the textbook model of the labour market. There is something ironic about teaching the First Welfare Theorem in a department operating far below its potential because of relationship problems.

Recently, I came across a published account of relationships within family businesses (Grant and Nicholson, 2008) that describes the volatility of relationships within firms. The authors discuss themes such as conflicts within firms and the interaction of culture and personalities, in addition to documenting over twenty accounts of conflicts. It is interesting that relationships with other people – important in our private lives and also in businesses and institutions – that business school students are taught how to handle do not feature prominently in economics. In fact, such real life accounts of life within firms do not sit well within economic theory. The economics profession has traditionally focused on the interaction between utility-maximising consumers and profit-maximising firms in markets, which is supposed to maximise social welfare according to the First Welfare Theorem – given certain conditions – subject to the stock of resources, the state of technology and the quality of institutions.

The objective of this paper is to incorporate relationships into labour economics by modelling how productivity, wages and profits may depend on the state and the volatility of relationships between people in the workplace, no less than on the conventional parameters of technology. Depending on the state of our relationships, we sometimes enjoy collaborating and contributing to group effort. Phelps (1972) made the distinction between monetary rewards and approval as two ways people show they value one another's services within the workplace. Moreover, that the contribution of individual members of a household to the

common good should rather be considered to be leisure, not contingent on any sign of approval. The same insight can be applied to other relationships. Depending on their state, we sometimes enjoy contributing even when we are not thinking of getting anything in return while in other cases we only do so in the expectation of a reward. It follows that there is a range of relationships within the workplace, starting with the one where workers contribute even when they do not expect anything in return, to the one where they contribute in order to receive the approval of colleagues, to the one where they only contribute to the extent that they receive monetary rewards, to the one where all collaborate breaks down due to mutual hostilities.

People influence how their relationships evolve but they are also influenced by the state of their relationships. In the household, the family atmosphere affects the wellbeing of its members.[1] The nature of these relationships in the workplace may also affect people and their productivity, no less than the level of technology and the organisation of work. A workplace may be uninspiring and lacking in motivation in spite of the employer's best effort to turn things around. Workplaces can also enhance productivity, originality and creativity. Business schools teach classes in industrial relations; personnel management and personnel economics that are meant to teach students how to create a productive working environment. Business professors write about the "psychological contract" that exists between employers and their employees, embodying the mutual expectations that exist at the start of an employment contract.[2] Clearly, this contract differs between workplaces and its breakdown will affect morale and productivity. Disappointments, misunderstandings and infighting all affect morale and the value of the workplace.

Newcomers may improve or damage relationships that exist in the workplace, lower standards or raise them, often in unpredictable ways. An overachiever may create feelings of envy and loss of confidence among co-workers and an overambitious worker may poison a workplace with politics and by striving for unrewarded promotions. Each workplace, at a given point in time, is thus endowed with a state of relationships that reflects the personalities of the current workforce, their interaction, the history of past interactions among current and past workers and the impact management has on relationships through its treatment of employees, the salary scheme, promotion decisions and so forth. Current events affect these

[1] As so memorably captured by Tolstoy in the first sentence of his Anna Karenina: "All happy families are alike; each unhappy family is unhappy in its own way."
[2] See Rousseau (2001) on this literature.

relationships, some more than others and they may also change in the absence of any particular events, a lack of stimulus and stagnation may make boredom set in.

Just as people may have a volatile temper, relationships may also be volatile. A large volume of books has been published on how to keep one's marriage alive. But volatile relationships also matter in the workplace. The question that arises is whether volatility among workers in the workplace can ever be desirable from an employer's point of view. Lazear (1998) argues that unpredictability may be a desirable trait in a new worker; a firm may prefer a high-risk worker to a predictably average achiever when the former can be fired at a low cost within a short period of discovering his true potential. However, to my knowledge, no one has explored the implications of volatile relationships in the workplace, whether the owners of a firm would under any conditions prefer a combustible workplace. We will see how some simple insights dating back to Adam Smith and Karl Marx are relevant in this regard.

1. The enigmatic "A"

In macroeconomics, the insertion of the magic letter *A* into the production function $Y=F(K, AL)$ does wonders in terms of explaining differences in per capita income Y/L across countries and the evolution of this ratio over time for each country. The interpretation of *A* has generated an expanding literature suggesting numerous hypotheses. The technology-augmented production function is also used in labour economics when explaining wage determination and labour demand. In both the macroeconomic as well as the microeconomic literature, *A* is taken to measure either the influence of technology or institutions.

The interpretation of *A* as capturing purely the effect of technology and institutions is challenged by a set of observations. First, casual observation suggests that productivity, work ethics and relationships differ between firms. For example, there are university departments plagued by current infighting, others by bitterness left by past conflicts, while in others cooperation is vibrant. Second, within-industry productivity differs across countries even when identical technologies and management methods are used. Clark (2007) documents productivity differences between firms located in developed and developing countries and Harvey Leibenstein (1982) mentions an article in the New York Times (October 13, 1981) where the productivity of two Ford automobile assembly plants is compared; a low-productivity one located in the US and another in Germany that produced 50% more with 22% less labour. Third, labour-productivity differs between OECD countries in spite of

similar institutions and access to similar technologies. One interpretation of these observations is that culture and norms differ between countries and that these factors, as well as the state of relationships, differ between firms within industries in any given country.[3]

Once we open up the possibility that differences in productivity across firms, industries, and countries are not only due to differences in the access to technologies and differences in the institutional environment, we are opening up the black box which is the internal workings of the firm. This is a subject studied in business schools but often hidden behind the magical *A* in economics texts. The black box, however, turns out not to be completely empty in the economics literature.

While modern economics textbooks do not have much to say about cooperation and relationships in the workplace, the classical economists came closer to the mark by emphasising the former. By facilitating cooperation, capitalists could make workers more productive, more so than the workers could achieve on their own. Karl Marx compared the productivity of a group of cooperating workers to "the offensive power of a squadron of cavalry, or the defensive power of a regiment of infantry," which was "essentially different from the sum of the offensive or defensive powers of the individual cavalry or infantry soldiers taken separately." In the 18th century Adam Smith described so vividly how the division of labour contributed to productivity by saving time that would otherwise be used to go from one task to another; making each worker an expert in the task that he or she performs; and promoting discoveries. A more recent contribution is that of Armen Alchian and Harold Demsetz (1972). They view the firm as a centralized agent that facilitates cooperation between workers who take advantage of differences in skill sets.

2. Model setup and assumptions

Following in the footsteps of Alchian and Demsetz (1972) we assume that workers collaborate in producing output and individual output is not measureable. Instead, managers observe the collective output of their workers and decide on remuneration in order to maximise the firm's profits. This constitutes in its pure form profit sharing, or, alternatively,

[3] The literature on norms, such as the seminal paper by George Akerlof (1982) on labour contracts being a partial gift exchange, does not fully capture the role of relationships in the workplace. According to his thesis, good workers express their sentiment towards their employer and inferior workers by performing better than required, establishing more ambitious work norms. In return they can expect the goodwill of both parties, in particular wages that are higher than what they can anticipate elsewhere. But this does not give full credence to relationships being a state variable that is to some extent distinct from the individuals involved, shaped by past events and the particular chemistry that exists between people. See also Mitchell and Abraham (1985), Perry (1986).

group bonuses, stock options or other forms of compensation that is based on team output. Our setup resembles that in the literature on profit sharing, see, amongst others, Weitzman and Kruse (1990).[4]

We first assume that workers work in pairs. Imagine couples in ballroom dancing where the performance of one person depends on that of the other. The number of such pairs is denoted by P. Nothing is lost by making this assumption but it simplifies the analysis. Each pair of workers collaborates by dividing up tasks and taking advantage of their individual-specific knowledge and experience. Output depends on effort and the extent of collaboration due to increasing returns stemming from the division of labour and/or differences in knowledge and skills between workers. The efficiency of a pair of workers is denoted by E_{ij} for workers i and j working together and is related to their effort levels e_i and e_j as described by the function below

$$E_{ij} = e_i + Ce_ie_j + e_j \tag{1}$$

where C is the productivity of a cooperative relationship between the two workers. Equation (1) has the plausible implication that the productivity of one worker depends on the effort of the other. Hence the marginal productivity of worker i is equal to $1+Ce_j$. A good example is a teacher working with a student in the production of education, where, clearly, the productivity of the teacher depends on the effort of the student and vice versa, as any teacher can testify, and the productivity of their relationship depends on the state of their relationship.

That production in a capitalist economy can be described by an equation akin to equation (1) has a long history in economics. Simply put, it says that two workers accomplish more in one day when cooperating than each would accomplish by himself in two days. This is Adam Smith's theory of the division of labour and same idea led Karl Marx to the conclusion that capitalists could exploit workers because their capital was a necessary condition for workers' cooperation and through cooperation workers became more productive than when working alone.

We let the productivity of cooperation C depend on technology T as well as personal attributes A: $C(T, A)$. Clearly, the productivity of a cooperative effort depends on the personalities and the cultural background of the two individuals. Speaking the same language is clearly important; being able to relate to one another is also important; having similar work ethics would be helpful; also, being able to compromise and resolve disagreement and conflicts; and having personal chemistry is helpful in fostering productive cooperation.

[4] For the macroeconomic implications of profit sharing, see Weitzman (1985).

The representative firm then decides wages *w* and employment *P* to maximise profits. We assume zero elasticity of substitution between *K* and *L* in the short run as described by a Leontief production function:

$$Y = \min\left[EP, K\right] \tag{2}$$

Wages are set by firms in order to affect effort so as to maximise current profits. They are measured as the fraction of output *E* that goes to the pair of workers that constitutes the production unit. Wages *w* are paid for collective team (pair) output (effort) since individual output is non-observable. The team collects 2*w*, which is split evenly between the two.

Utility is additive in wages and the disutility of effort e^{γ}/γ where $\gamma>1$. It is linear in wages and additive in wages and the disutility of effort;

$$u = w - 1/\gamma e^{\gamma}, \ \ \gamma > 1 \tag{3}$$

3. The effort decision

Management has to decide how to share output with the pair of workers. In this they are trading off the utility of workers against profits. Workers, knowing this, will adjust their effort based on the management's decision, taking into account their disutility of effort. When management takes a larger piece of the pie, workers reduce their effort and the pie shrinks. It follows that there is a profit-maximising efficiency wage. We will describe the representative workers' decision problem and later describe the firm's profit-maximising problem.

Workers adjust their effort levels in order to maximise utility from working net of the disutility of effort

$$\max_{e_i} \ wE - \frac{1}{\gamma} e_i^{\gamma} \tag{4}$$

The first-order conditions set the marginal utility of raising effort equal to zero

$$w\left(1 + C\left(T, A\right) e_j\right) - e_i^{\gamma-1} = 0, \qquad i, j = 1, 2 \tag{5}$$

which gives effort as a function of wages and the partner's effort level and the importance of collaboration *C*.

$$e_i = \left(w\left(1 + C\left(T, A\right) e_j\right)\right)^{\frac{1}{\gamma-1}}, \qquad i, j = 1, 2 \tag{6}$$

Effort is increasing in *w* and the partner's effort and decreasing in the marginal disutility of effort which depends on γ.The Cournot solution to this problem is shown in Figure 1 below for γ=2. The two reaction curves intersect at

$$e_i = e_j = \frac{w}{1 - C(T, A)w} \tag{7}$$

Effort is clearly rising in wages. Higher wages have the effect of shifting the two reaction curves and raising the slope. Effort is also increasing in the effectiveness of collaboration *C*.

A wage increase has a multiplier effect on effort in that when both parties raise their effort level, each has an additional incentive to do more work since his marginal benefit from raising effort is higher the greater the effort exerted by one's partner. The impact of wage changes on effort depends on the extent of collaboration within the firm, the extent to which the division of labour causes scale economies and the extent to which differences in skills and knowledge sets create scope for teamwork within the firm, all captured by function *C*. This effect will henceforth be referred to as the "effort multiplier".

Figure 1. The Cournot solution

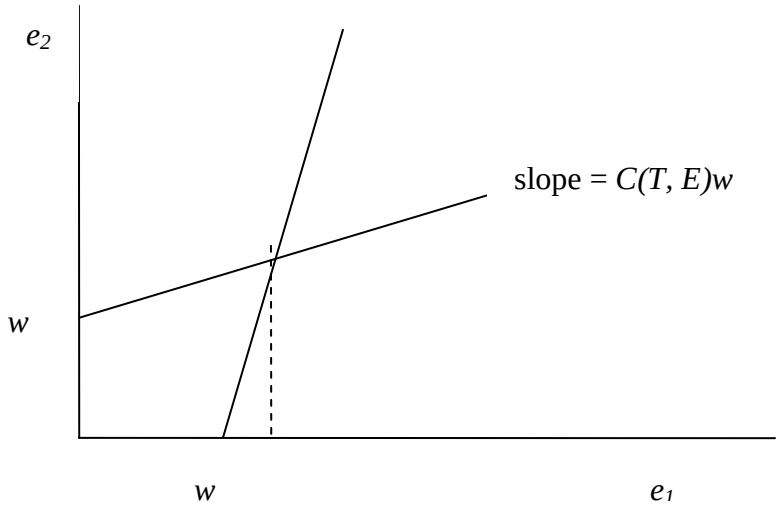
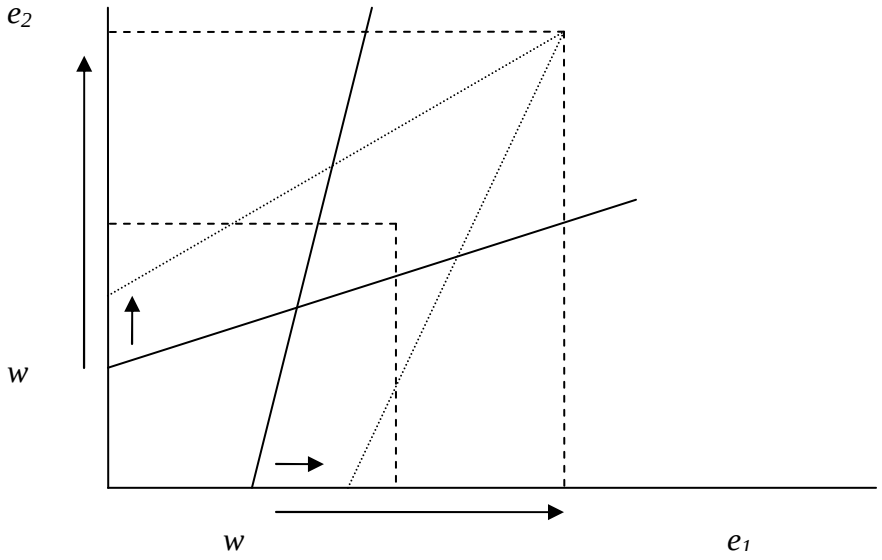


Figure 2. The effect of higher wages



Were the workers to cooperate in order to maximise the total wage bill $2wE$, they would each exert greater effort given the effort of the other;

$$e_i = \left(2w\left(1+C\left(T,A\right)e_j\right)\right) , \qquad i, j = 1, 2 \tag{8}$$

which gives the solution

$$e_i = e_j = \frac{2w}{1-2C\left(T,A\right)w} \tag{9}$$

We have found that the workers face a prisoner's dilemma. If both workers cooperate they get more utility than if they behave non-cooperatively, but if one cheats and the other one cooperates the former gains a lot more while the latter loses out. There are gains from cheating in the workplace.[5] Clearly, each set of partners would be better off cooperating, while each individual has an incentive to cheat.

Harvey Leibenstein (1982) describes the effort decision in a cooperative setting as a prisoners' dilemma where effort conventions and fairness act as solutions to game theoretical

[5] For w=0.5 the non-cooperative Cournot solution gives e_1=e_2=0.14 while the cooperative solution gives e_1=e_2=0.33. The corresponding utility levels from equation (3) are 0.05 for the non-cooperative solution and 0.08 for the cooperative solution. Effort would thus be more than twice as great were they to cooperate and the utility of the worker would be more than 50% higher. However, when one worker betrays the trust of the other and cheats he ends up working e=0.17 getting utility of 0.11, that is 38% more. If both cheat we are back to working e = 0.14 for both workers, getting utility of 0.05.

coordination problems.[6] Frank (2005) describes the results of a social experiment where the formation of a relationship through time spent together affects the probability that two partners choose the cooperative solution. He also finds that many people have the ability to selectively interact so as to pair off with other cooperating individuals. Other authors have documented how two people can reach a level of mutual understanding and trust so that each will collaborate in one-stage prisoner's dilemmas. The gradual build-up of trust in the workplace will reduce the frequency of non-cooperation.

A worker who chooses to collaborate – behaves according to equation (9) instead of equation (7) in spite of individually gaining more from non-cooperating – contributes to an improvement in relationships in the workplace and may gain in the future. The likelihood of this occurring is greater the smaller the workplace is. Not surprisingly, workers who are new on the job are more affected by the experiences of cooperative and non-cooperative behaviour by colleagues. Such bad experiences during formative years may then have an effect on workers that makes them both perform worse as individuals in the future as well as having a detrimental effect on the state of relationships in their workplace.[7] Good productive relationships may also make work more pleasant and instil a feeling of guilt for those shirking their duties.

Following Phelps (1972) I distinguish between relationships where people enjoy volunteering their contribution to a group effort; where they only do so in the expectation of a psychic reward in the form of an approval; to the one where they only contribute in the expectation of a monetary reward. In the marriage context, which was Phelps's focus, the partners contribute to the household on altruistic grounds, not in the hope that their effort will be approved of. Extending her insights to the workplace, good relationships encourage workers to exert effort since in this case a worker gets nonmonetary utility from contributing to the group output either on altruistic grounds or because colleagues can reward effort by expressing their approval. People who enjoy working together exert more and accomplish more in the absence of wage incentives. Relationship breakdowns then consist of workers not

[6] See also review by Andrew Schotter (1981).

[7] Results from game theory show that if we allow for a repeated game, where workers remember at least the outcome of the past game, the optimal strategy may be for the workers not to cheat all the time. Aumann (1959) found that the cooperative outcome could be sustained in a repeated game. Experimental results from playing prisoner-dilemmas games show decisions that are influenced by the past experience of the players. Axelrod (1984) reports the results of a tournament where chronic cheaters tended not to do too well in contrast to the ones who behaved in an apparently more altruistic manner. The best strategy often turned out to be the so-called "tit for tat" strategy which consisted of starting with a cooperative in the first round and then do what the opponent did previously. See Axelrod (1984), *The Evolution of Cooperation* .

wanting to contribute, not appreciating signs of approval from colleagues or, in the extreme case, even withdrawing effort when monetary rewards are offered.

The influence of relationships is captured by adding the term $\pi(R)e_i$ to equation (4) where $\pi(R)$ has a positive first derivative.[8,9]

$$\max_{e_i} \quad wA - \frac{1}{\gamma} e_i^{\gamma} + \pi(R)e_i \qquad i = 1, 2 \tag{10}$$

Maximising with respect to e_i gives the following first-order conditions,

$$w\left(1 + C(T, A)e_j\right) - e_i^{\gamma-1} + \pi(R) = 0, \qquad i, j = 1, 2 \tag{11}$$

which gives effort as a function of wages and the partner's effort level.

$$e_i = \left(w\left(1 + C(T, A)e_j\right) + \pi(R)\right)^{\frac{1}{\gamma-1}}, \qquad i, j = 1, 2 \tag{12}$$

The Cournot solution is now the following for γ=2;

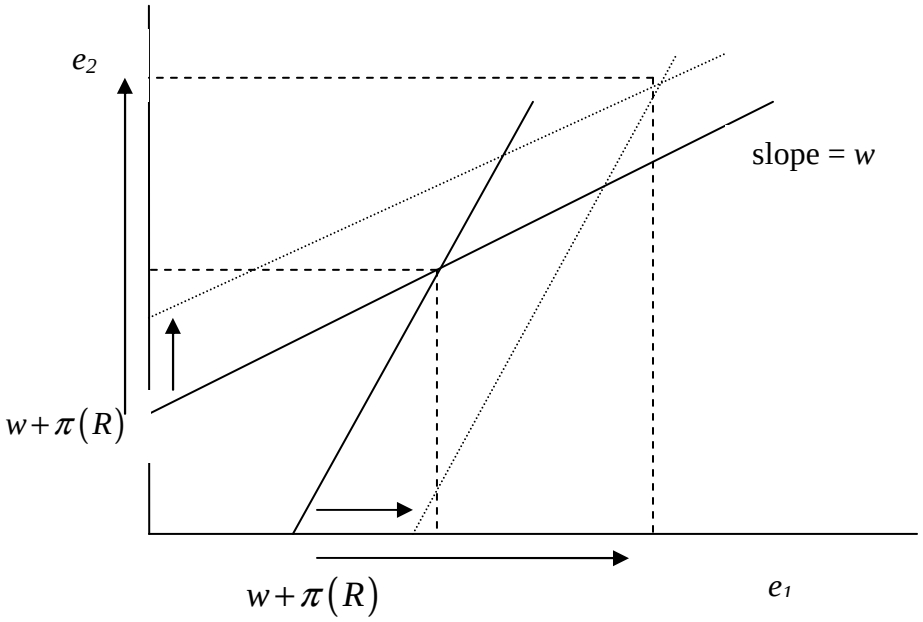
$$e_i = \frac{w + \pi(R)}{1 - wC(T, A)}, \quad i = 1, 2 \tag{13}$$

Relationships more conducive to work will manifest themselves in a higher value of π and shift both reaction curves in Figure 3. This will generate increased effort through the effort multiplier where, in the first round, both workers decide to raise their level of effort which then induces both workers to provide further effort and so on until their effort level has increased by a multiple of the initial increase.

[8] Gunnthorsdottir, Vragov and Mccabe (2007) explore the role of meritocracy in generating effort where workers' performance is affected by their desire to move on to more prestigious establishments with more productive co-workers.

[9] Here we follow Kandel and Lazear (1992) who describe how guilt and sanctions affect workers' behaviour on the job.

Figure 3. The effect of improved relationships.



We have found that productive relationships that induce workers to increase their effort can help resolve the prisoners' dilemma in this case.

4. Wage setting and labour demand

Firms set wages. The representative firm has a Leontief production function in the short run $Y=\min(EP,\mathrm{K})$, which gives the following short-run maximisation problem:

$$\max_{w} \Pi = E(w)P - wE(w)P = (1-w)E(w)P \tag{14}$$

Wages are set so as to maximise profits, setting the marginal benefit of wage increases – in the form of increased effort – equal to the marginal costs – in the form of a higher wage bill;

$$-E(w)P + (1-w)E'(w)P = 0 \tag{15}$$

or;

$$\frac{E'(w)(1-w)}{E(w)} = 1, \tag{15'}$$

This is analogous to the elasticity condition of Solow (1979). [10] Using equation (9) above one

[10] The second-order conditions are also satisfied: $A_{ww}(1-w) - 2A_w = -\frac{-6+2C(1-w)}{(1-w)^3} < 0$.

can rewrite the equation as

$$\frac{1-6w+2w^2C(T,R)}{\left(1-wC(T,R)\right)^2} = 0 \tag{16}$$

Since $w \in (0, 1)$ we have found that for C=1 we get w=0.17, that is 17% of output is given to each of the two workers, leaving 66% for the employer. The wage turns out to be rising in the value of the function *C*, the higher is the value of *C* the higher is the optimal wage. It is then straightforward to find the number of pairs of workers that the firm employs with capital stock *K* or $P^*=K/E^*$.

Relationships more conducive to effort will affect the optimal wage defined by equation (16). Combining equations (1), (13) and (16) for $C = 1$ gives the following equation (17) which has the marginal benefit of raising wages on the left-hand side and the marginal cost of raising wages on the right-hand side.

$$2\frac{1-2w}{1-w}\left(\frac{1+\pi(R)}{1-w}\right)^2 = \left(\frac{1+\pi(R)}{1-w}\right)^2 - 1 \tag{17}$$

or;

$$\frac{1-3w}{1-w}\left(\frac{1+\pi(R)}{1-w}\right)^2 + 1 = 0 \tag{18}$$

One can now take the total differential of the equation to derive the effect of an improvement in the relationship variable π on the optimal wage (see appendix for derivation).

$$\frac{dw}{dR} = -\frac{\pi'(R)\left(2-4\left(4+2\pi\right)\right)(4-w)}{(4-w)\left(1-(4-w)\right)-\left(14\pi-w+16+4\pi^2\right)} < 0 \tag{19}$$

Note that $0<w<1$ which makes the numerator negative as well as the first term in the denominator. Also the second term is positive with a minus sign in front. Hence both numerator and denominator are negative making the ratio positive. The minus sign in front of the ratio makes the derivative negative.

We find that a higher *R* makes the optimal wage go down. In other words, the employer should lower the wage when the state of relationships improves and workers raise their effort level. Intuitively, the greater effort raises the marginal disutility of further effort making wage increases less effective at raising effort further. This intuition fits the observation that workers performing morally – satisfying tasks that attract voluntary workers – pay less than those that

are onerous or ignoble. The same applies to relationships; good, productive relationships reduce the need for wage incentives, in fact make them less effective and more costly.

In addition, the model provides one explanation for the empirical observation that large firms pay higher wages, ceteris paribus. In large firms, relationships in the workplace may have a weaker effect on workers' incentives, in particular any system of rewards and sanctions will be less effective than in smaller enterprises.

5. Volatility

We now come to the effect of the volatility of effort on firms' profits. Clearly, human relationships and expectations are prone to sudden swings. Assume that the state of relationships is a random variable which has the uniform distribution with a minimum of *a* and a maximum of *b*.

$$\pi(R) \sim U(a, b) \tag{20}$$

Effort is a function of the cultural variable π;

$$e = \frac{w}{1-w} + \frac{\pi(R)}{1-w} = E_0 + E_1\pi(R) \tag{21}$$

We can then derive the expected level of effort, which is

$$E(e) = E_0 + E_1\frac{b+a}{2} \tag{22}$$

In order to calculate expected profits, one need to derive and expression for expected productivity. In a symmetric equilibrium when C=1, this equals

$$E = e + e^2 + e = (1+e)^2 - 1 \tag{23}$$

Taking the expectation gives

$$E(E) = \frac{(1+E_0+E_1b)^3 - (1+E_0+E_1a)^3}{3E_1(b-a)} - 1 \tag{24}$$

which yields

$$E(E) = \frac{(b-a)(6E_0E_1 + 4E_0^2E_1) + (b^2-a^2)(3E_1^2 + 3E_0E_1^2) + (b^3-a^3)E_1^3}{3E_1(b-a)} \tag{25}$$

which can be simplified to

$$E(E) = 2E_0\left(1+(2/3)E_0\right)+(b+a)\left(E_1 + E_0E_1\right)+\frac{\left(b^3-a^3\right)E_1^2}{3(b-a)} \quad (26)$$

Now assume that $b = \theta + f$ and $a = \theta - f$ so that $E(\pi) = \theta$. Consider an increase in f which makes relationships less predictable, the best outcome is better than before and the worst outcome worse than before. This can be taken to measure our level of ignorance about how work ethics will evolve.

Taking the derivative of the equation above with respect to f gives;

$$\frac{dE(E)}{df} = \frac{E_1^2}{6}\frac{3\theta^2+5f^2}{f} > 0 \quad (27)$$

This shows that making relationships more volatile will raise the expected productivity of labour. It follows that the wage paid to each worker is also higher the more volatile is R since the wage in units of output is $wE(E)$. It is due to the increasing returns of effort that a worker who operates in a volatile working environment is more valuable than one who finds himself in a stable environment. This mirrors the results of Lazear (1998) who found that high-variance workers were preferable to low-variance ones because they could be laid off if they were underperforming. In contrast, volatility is preferable in our context because of increasing returns to effort.

6. Conclusions

We have found that productivity E depends on relationships within the workplace. These can induce workers to cooperate which benefits them collectively as well as the owners of the firm. Bad relationships, in contrast, make people behave selfishly by cheating and withdrawing collaboration to the detriment of the workplace. A few interesting implications followed.

Relationships that foster collaboration make the optimal efficiency wage fall. In this way, good relationships within a firm constitute an asset that enhances the firm's value. Moreover, volatile relationships raise expected (group) productivity because of increasing returns to effort. When both workers in a team raise their effort by a certain percent, the team output goes up by more because of their collaboration that takes advantage of different skill sets. It follows that workers with more volatile relationships have higher wages because of the higher expected productivity.

I conclude that in my own department I will in the short term need to use wage incentives and reward generously the occasional burst of energy while in the long term an improvement of working relationships will bring enhanced productivity even without such incentives.

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Appendix: The effect of relationships on wages, dw/dπ.

We start off by defining the effort function for a pair of workers,

$$A = e_i + e_i e_j + e_j, \quad i,j = 1, 2 \tag{A1}$$

Workers maximise their utility – wages net of effort and social pressure – and their optimal effort is described by the following equation;

$$e_i = \frac{w + 2\pi}{4 - w}, \quad i = 1, 2 \tag{A2}$$

The representative firm then maximises profits with respect to the wage paid and gets the following first-order condition,

$$-A(w)P + (1 - w)A'(w)P = 0 \tag{A3}$$

Which has the marginal benefit from raising wages – in the form of higher effort, hence productivity A – equal to the marginal costs– in the form of a higher wage bill. Inserting the effort function (A2) and the definition of productivity (A1) into the first-order condition gives,

$$2(1 - w)\left(\frac{4 + 2\pi}{4 - w}\right)\left(\frac{1}{(4 - w)^2}\right) = \left(\frac{4 + 2\pi}{4 - w}\right)^2 - 1 \tag{A4}$$

We next add and subtract 1 within each of three parentheses,

$$2(1 - w)\left(1 + \frac{w + 2\pi}{4 - w}\right)\left(1 + \frac{1 - (4 - w)^2}{(4 - w)^2}\right) = \left(1 + \left(\frac{4 + 2\pi}{4 - w}\right)^2\right) - 1 \tag{A5}$$

then take logs to get

$$-w + \frac{w + 2\pi}{4 - w} + \frac{1 - (4 - w)^2}{(4 - w)^2} = \frac{(4 + 2\pi)^2}{4 - w} \tag{A6}$$

Taking the total differential with respect to w and π gives (A7);

$$\left[\frac{2}{4 - w} - \frac{4(4 + 2\pi)}{4 - w}\right]d\pi + \left[-1 + \frac{2\pi + w}{(4 - w)^2} - \frac{1}{4 - w} + \frac{2(4 - w)}{(4 - w)^2} + \frac{1 - (4 - w)^2}{(4 - w)^4}2(4 - w) - \frac{(4 + 2\pi)^2}{(4 - w)^2}\right]dw = 0$$

which gives

$$\frac{dw}{d\pi} = -\frac{(2 - 4(4 + 2\pi))(4 - w)}{(4 - w)(1 - (4 - w)) - (14\pi - w + 16 + 4\pi^2)} < 0 \tag{A8}$$

So that better relationships in the workplace which are more conducive to effort will lower the optimal wage.

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