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Piece Rates and Workplace Injury: Does Survey Evidence Support Adam Smith?*

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Abstract

While piece rates are routinely associated with higher productivity and wages, they can also generate unanticipated effects. Using cross-country European data, we provide among the first broad survey evidence of a strong link between piece rates and workplace injury. Despite controls for workplace hazards, job characteristics and worker effort, piece rates workers suffer a 5 percentage point greater likelihood of injury. This remains despite attempts to control for endogeneity and heterogeneity. As piece rate wage premium estimates rarely control for injury likelihood, this raises the specter that part of that premium reflects a compensating wage differential for risk of injury.

Keywords: piece rate, injury, incentives

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"*Workmen…when they are liberally paid by the piece, are very apt to overwork themselves, and to ruin their health and constitution in a few years*" (Smith, 1776, p.83).

1 Introduction

The notion that performance pay and piece rates, in particular, increase productivity stands well-ingrained in the theoretical and empirical literature. More than a dozen case studies from tree-planting, food-processing, physician services, windshield replacement, retail firms, shoe manufacturing and steel production confirm that the introduction of such schemes is associated with increased worker productivity or that the removal of such schemes is associated with decreased productivity (see for instance Lazear 2000; Banker et al. 2001; Haley 2003; Jones et al. 2010; Gielen et al. 2010; and the cites within Frick et al. 2008). Also well ingrained, but not nearly as well tested, is the idea that the increases in productivity may be offset by other worker behavior that hurts profitability and efficiency. Thus, Freeman and Kleiner (2005) emphasize that piece rates generate incentives to skimp on quality and to use excessive materials. Piece rates also reduce the incentive for workers to share valuable information. Moreover, frequent technological or product line changes can cause a "demoralized" piece rate often out of line with the opportunity cost of labor. Finally, piece rates provide workers an incentive to increase their speed and to take greater risks increasing the probability of injuries on the job.

We examine European survey data on this final influence identifying large and robust positive partial correlations between injuries and the presence of piece rate schemes. We show that the risk of injury remains elevated in the presence of piece rates even when controlling for country fixed effects, detailed occupational and industry controls, worker controls, complex error structures and detailed measures of workplace hazards. We identify a variety of specific injury and health measures that are associated with piece rates and show that piece rates are associated with working under more pressure and at a faster pace. We show that while this pattern exists for piece rates, it is not replicated for other measures of performance pay such as profit sharing or subjectively evaluated bonuses that are not uniquely tied to output and so generate different incentives. We provide a series of tests to check for heterogeneity in our estimates by country and industry. Finally, we attempt to correct for the possible endogeneity of piece rates yet continue to find higher risk of injury for those on piece rates.

The importance of our finding is several-fold. First, the strong, robust relationship between injuries and piece rates suggests that the benefits to firms of increased productivity may be partially offset by higher costs for workers compensation / sickness insurance payments (increased premiums paid to public or private schemes). Second, the relationship we find suggests that the frequently estimated wage premium for piece rates (Pekkarinen and Riddell 2007; Parent 1999; Seiler 1984) may be, in part, a return to greater risk of injury. In this way, piece rates serve as a mechanism for workers to capture compensating differentials, not simply to be rewarded for greater effort.[1] Third, to the extent that there are public good rationales for the creation and enforcement of health and safety regulations, our findings point to piece rate jobs as being particularly relevant for attention. Critically, the results do not demonstrate that workers paid piece rates are worse off or have lower job satisfaction, only that the injury rates appear higher (Green and Heywood 2008).

In what follows, we briefly review the relationship between piece rates and injury emphasizing that there has been virtually no use of broad survey data to explore this relationship. The third section presents our data which has unusually good information on injuries, hazards and payment schemes. The fourth section presents our empirical approach while the fifth section establishes the robust and large relationship between piece rates and a heightened risk of workplace injury. We follow this by instrumental variable estimation to account for the endogeneity of piece rates. A short sixth section describes both exploratory estimates of the relationships between earnings, piece rates and injury and the limitations within our data for successfully makings such estimates. The final section concludes and suggests avenues for future research.

2 Background

The idea that piece rates cause injuries is as old as modern economics. Adam Smith makes clear that "Workmen…when they are liberally paid by the piece, are very apt to overwork themselves and to ruin their health and constitution in a few years" (Smith 1776, p.83). In a simple agency model of piece rates, the principal faces a worker utility constraint from the labor market and so sets the earnings contract such that it just offsets effort and earnings risk costs leaving workers equally satisfied as without piece rates (e.g., Holmstrom and Milgrom 1987; Gibbons 1998). Presumably in such a model, allowing for the increase in injuries associated with increased output or speed of production requires an even more generous piece rate to offset not only effort and earnings risk costs but to compensate for the greater probability of injury. Thus, if a firm finds the increased output sufficient to pay such compensation, we would anticipate that the resulting piece rates are associated with greater output, earnings and injury risk.

In alternative models, Lazear (1986) and Booth and Frank (1999) among others model piece rates as generating a self-sorting process by workers of heterogeneous abilities. The firms face a zero profit market constraint allowing workers with greater ability to capture the rent associated with their ability by sorting into performance pay. In a similar way, those with lower inherent probability of injury may also be more likely to sort into piece rates to capture the associated rent.[2] At the same time, if piece rates serve as a mechanism to earn compensating differentials, those who sort in may be those with the least aversion to risk.[3] Thus, these two types of sorting could create offsetting influences by attracting those with reduced inherent probability of injury but also attracting those who least mind the risk and so may take more risk. These two offsetting influences stand beside the pure incentive effect of a given worker to take on additional risk of injury when there is a reward to do so by exerting effort under a piece rate scheme.[4]

Thus, we recognize that the observed probability of injury may reflect the individual worker specific characteristics of inherently more accident prone. This recognition mimics that behind the association of piece rates with productivity. Piece rates may attract the more productive and also increase worker productivity regardless of inherent productivity (ability). The typical way to distinguish between these two complementary tendencies involves the use of repeated observations on individuals that allow controlling for individual fixed effects as piece rates are introduced (Lazear 2000). We do not have repeated individual observations and so our attempt to control for endogeneity may not hold constant the individual specific component of being injury prone. Yet, we note that if piece rate jobs are inherently more dangerous, it seems unlikely the more accident prone will be attracted to these jobs suggesting that this type of selection may not be a serious problem. As stressed, the less risk averse may be attracted to piece rate jobs and so the theoretically critical issue may be the correlation between being less risk averse and being inherently more accident prone upon which we have no information or strong priors.

While the exact paths of causation may well vary with the model, the suggestion by Adam Smith that workers facing an output based incentive will take risks with their health cannot be easily ruled out and seems worthy of empirical inquiry. The number of past studies that explore this suggestion is minimal and typically done by occupational health specialists focusing on narrow industries or occupations in specific locations. Thus, Sundstroem-Frisk (1984) studies the transition from piece rates to hourly earnings among Swedish loggers finding that the former was associated with significantly higher accident rates. Toupin et al. (2007) present evidence on heart rates from tree cutters in Canada showing that piece rates cause workers to dramatically increase their intensity in less difficult plots in order to make "easy money." The resulting heart rate data suggested "negative consequences for worker health and safety." A five year medical study of workers in fertilizer production in India concludes that piece rate workers are more vulnerable to occupational accidents (increased probability and severity of an accident) than otherwise similar time rate workers (Saha et al. 2004, p. 240). The authors suggest a path of causation from the financial incentive to the speed of work to the increased accident risk. Evidence has also been presented suggesting increased risk for over-the-road truckers in the United States paid by the mile (Williamson et al. 2009; Rodriquez et al. 2006; Belman et al. 2005; Monaco and Williams 2000). While the evidence is not unanimous, Monaco and Williams (2000) find that hourly wage drivers have significantly smaller probabilities of being in an accident and of violating safety standards even when controlling for training, demographics, firm size and type, unionization, characteristics of the vehicle and actual miles being driven.

Indirect evidence on the link between piece rates and injuries can be found in the shoe manufacturing case study by Freeman and Kleiner (2005) who present simulations indicating that piece rates are associated with much higher Worker's Compensation costs. Further indirect evidence comes from Foster and Rosenzweig (1994) who focus on a link between piece rates and overall health for agricultural workers. They use data from Pilipino farmers and proxy health with the body mass index (BMI) showing that farm workers paid piece rates have lower BMI values (worse health) after controlling for calorie intake, illness, lagged BMI, and other variables.

Completely missing from the existing research is the use of broad individual worker panel surveys employed extensively by labor economists. These sources typically do not include both reasonable individual measures of work related injury and specific designations of workers being paid piece rates. Thus, while the National Longitudinal Study of Youth and Panel Study of Income Dynamics allow identification of piece rate workers for some or all years, they do not include injury at work data. The German Socio-Economic Panel lacks the injury data and has only an aggregated performance pay measure that subsumes schemes not linked to output and so unlikely to generate the same incentives. The British Household Panel Survey has only broad measures of performance pay and lacks specific information on workplace injuries. The Health, Income and Labour Dynamics in Australia Survey contains very detailed indicators on health status and injury but is less satisfactory at tying them to work and contains no information on performance pay at all.

3 The European Working Conditions Survey

We draw data from the 3rd and 4th waves of the European Working Conditions Survey (EWCS), conducted in 2000 and 2005, respectively. The EWCS is conducted by the Foundation for the Improvement of Living and Working Conditions, a European Union (EU) body created in 1975.

Each wave of the EWCS represents a new cross section survey of individual workers within Europe asking detailed information about the nature of their jobs and working environment. The initial cross section, in 1991, covered only the 15 then member EU countries. In the third wave workers from the 12 soon to accede countries were added. By the fourth wave this was further expanded to include Turkey, Norway, Croatia and Switzerland.[5] The EWCS oversamples workers in small countries but contains detailed weights to adjust for the relative likelihood of workers appearing in the sample. All of the empirical estimates we present use these weights but the tenor of results does not depend upon doing so.

The key advantage of the EWCS is that it contains detailed information on payment methods, injury arising from work and an extremely wide reaching set of working conditions that represent potentially important control variables. Specifically, we are able to observe if workers are paid by (i) piece rates and productivity payments; (ii) profit shares; (iii) share payments; or (iv) group bonuses. Thus, the piece rate variable does not include other measures of performance pay not linked to output that are unlikely to generate the same incentives. Yet, enough of these other measures exist in the survey to test the hypothesis that, indeed, piece rates are unique in the incentives they do generate. Respondents report whether or not their work affects their health and if so how. We take the response 'injury(ies)' as our main indicator of workplace injury. Respondents also provide a range of more specific details covering whether over that time work has caused specific physical injury and mental health conditions. In the empirical estimation we rely upon the former as our key dependant variable of interest, although we also demonstrate a pattern of response to the specific health questions that supports the role of piece rates in increasing the chance of certain types of injury. The information on working conditions is remarkably detailed covering a range of hazards associated with the working environment. These include exposure to vibrations, noise, adverse temperatures, smoke/vapors, heavy lifting, chemicals or radiation, tobacco smoke, infectious disease, tiring positions, standing and repetitive tasks. As suggested, these might influence the chance of injury and may be correlated with the use of piece rates. As such, their absence could represent significant omitted variable bias. There is also information on the nature of work tasks themselves. Previous literature demonstrates that piece rates are most likely to be implemented in jobs with particular task types such as simple and repetitive tasks that do not involve team work and are often considered monotonous (Parent 2002). The EWCS provides detailed information along these lines. Finally, a key theoretical incentive effect of piece rates is on worker effort. It is increases in effort that may increase workplace injury rates. Again the EWCS provides quite detailed information regarding working speed and effort.

In this paper we use the 3rd and 4th waves of the EWCS as earlier waves do not contain information on workplace injuries. We further exclude workers who are self-employed, older than 65 or work in the public sector. Once these observations are removed and accounting for non-response in key variables, we are left with 34,044 worker observations. Selected summary statistics are reported in Table 1.

INSERT TABLE 1

Over thirteen percent of workers are paid piece rates. For illustrative purposes we split the sample statistics by workers receiving and not receiving piece rates. The workplace injury rate for piece rate workers is 14.4 percent, nearly double the 7.5 percent reported among non-piece rate workers. Piece rate workers work longer hours and are concentrated in manufacturing. There are essentially no differences in tenure and age. Manual workers (blue collar) have much higher rates of both piece rate use and injury incidence leading us to focus in more detail on these workers in the results.

4 Empirical Approach

We focus on the role played by piece rates in increasingly complete specifications of the determinants of injury. We begin by showing that personal characteristics including tenure and hours play only a modest role and that piece rates retain a large marginal effect. We then narrow the sample by focusing on manual workers (while showing the influence for non-manual workers). We will then control for aspects of individual behavior which may be partially explained by the incentives created by piece rates. Thus, we have indicators of workers' ability to choose their speed and their own self-evaluated pace of work. We also know when they have worked long hours. These are at least suggestive of the effort and speed dimensions that are anticipated to respond to piece rates and may also increase the risk of injury.

We next recognize that piece rates are more likely where measurement costs are low. As a consequence, we next control for task indicators such as monotony and repetition. Such indicators are likely be both correlated with piece rates (Parent 2002) and associated with greater injury risks through loss of concentration. We follow this by accounting for work place hazards. These will be shown to be important determinants but not to dislodge the role of piece rates.

Appendix Table A1 shows descriptive statistics on these important controls divided by the receipt of piece rates. The workers on piece rates, which we know have a greater injury rate, also have jobs that are more likely to be monotonous and repetitive. They also work longer and at higher speeds. This is especially evident when they have jobs that they identify as allowing them to choose their own speed of work.

Thus, broadly, we conceive of the determinants of injury as worker characteristics, work speed and effort, task characteristics, exposure to hazards and the presence of piece rates. Again, we recognize that piece rates may mitigate agency problems by creating incentives to work harder or faster. Thus, controlling for measures of speed and effort may over-control as these may be the channels through which piece rates increase the risk of injury. Yet, piece rates are well known to more broadly generate adverse specialization (MacDonald and Marx 2001) in which workers perform only those aspects of the job that are best rewarded ignoring other aspects. Thus, a piece rate may not reward machine maintenance, the taking of work breaks, the visiting the infirmary for minor issues or many other job aspects that would otherwise reduce the risk of a reported injury. Indeed, to the extent that a role for piece rates remains after controlling for speed and effort, it may reflect either our inability to fully control for effort or that this broader type of adverse specialization is associated with risk of injury.

Our estimations can be expressed as variants of the following equation:

$$I^*_{ijt} = \alpha_0 + \beta X_{ijt} + \delta W_{ijt} + \phi PayType_{ijt} + \tau Effort_{ijt} + \theta Task_{ijt} + \lambda Haz_{ijt} + \eta_j + \sigma_t + \varepsilon_{ijt} \qquad (1)$$

where *i*, *j* and *t* index workers, countries and years. *I* is the risk of injury, *X* is a vector of personal characteristics, *W* is a vector of work-related characteristics including occupational and industry dummies, *Pay Type* is a vector of performance related pay schemes including piece rates, *Task* is a vector of task type indicators, *Haz* is a vector of workplace risk factors, η_j are country specific fixed effects and σ_t are year fixed effects. As mentioned, we will build up toward this full specification. In all cases the likelihood of being injured at work is an unobserved latent variable I_i^* that is proxied by the dichotomous injury indicator assumed to be one above a threshold, *k*: $I_i = 1$ if $I_i^* > k$, $I_i = 0$ otherwise. We will present the marginal effects for each probit estimate to allow easy comparisons of magnitudes. Moreover, all estimates use the sample weights that are critical for adjusting for the over-sampling of smaller countries.

We recognize two limitations before presenting our estimates. First, workers who suffer particularly severe workplace injuries (including death) will not appear in the EWCS which only samples current workers. If more severe injury types are highly correlated with piece rates our point estimates may be biased down. Second, in the absence of panel data, we cannot distinguish between incentive and sorting influences. Previous literature emphasizes the role of worker sorting across payment types according to risk preferences (Curme and Stefanec 2007; Cornellissen et al. 2011). Thus, our large positive correlations may be some combination of piece rates causing workers to take on new risk and workers who engage in inherently risky behavior being attracted to piece rates. At the same time, workers who are inherently less likely to be injured will be attracted to piece rates as they can capture returns to effort and risk at lower cost. Thus, the potential sorting dimensions have off-setting influences of unknown size.

We seek to control for the potential endogeneity of piece rates by estimating individual injury risk while instrumenting the likelihood of receiving a piece rate simultaneously. An added complication is that both dependent variables are binary leading us to estimate via a recursive bivariate probit. Following from Heckman (1978) and Maddala (1983) there exists a reduced form equation for piece rates as the potentially endogenous variable and a structural form equation estimating the risk of injury. Suppressing the subscripts for year and country this can be expressed as:

$$y_{1i}^{*} = B_1^{'} x_{1i} + \mu_{1i} \qquad (2)$$

$$y_{2i}^{*} = B_2^{'} x_{2i} + \mu_{si} = \delta_1 y_{1i} + \delta_2^{'} z_{2i} + \mu_{2i}$$

where y_{1i}^{*} and y_{2i}^{*} are latent variables for piece rate use and injury provision with y_{1i} and y_{2i} dichotomous variables observed according to the rule:

$$y_{ki} = 0 \text{ if } y_{ki}^{*} > 0 \text{ and } y_{ki} = 1 \text{ if } y_{ki}^{*} \leq 0 \text{ for } k = 1,2 \tag{3}$$

In (2) x_{1i} and z_{2i} are vectors of exogenous variables and the error terms (μ_{1i}, μ_{2i}) are distributed bivariate normal with correlation coefficient ρ. Estimates of, and inference on, the parameters ($B_1^{'}, \delta_1, \delta_2^{'}, \rho$) follow directly from the maximum likelihood method and the relevant log-likelihoods (Maddala, 1983, p. 123) with the likelihood ratio test (LR) typically providing the most suitable test for the exogeneity of y_{1i} (Monfardini and Radice 2008).

$$H_o : \rho = 0 \text{ vs. } H_a : \rho \neq 0 \tag{4}$$

However, use of the sampling weights in our estimates requires pseudo log-likelihoods with the Wald test routinely recommended for testing exogeneity (Korn and Graubard, 1990; Wooldridge 2002).

Despite the recursive structure, Wilde (2000) demonstrates that identification can often be achieved by the non-linearity alone. Nonetheless, Monfardini and Radice (2008) show that adding a suitable instrument to the first equation remains critical in applied work as it preserves the validity of the exogeneity test when the distribution of errors is non-normal as can often be expected. As a consequence, we follow the instrumental variable estimation of (2) by adding suitable controls to x_{1i} that do not belong in z_{2i}. We discuss the exact specification when we introduce our estimates in the next section.

5 Results

Table 2 presents the marginal effects from probit estimates of the determinants of workplace injury. Each of the performance pay indicators is included along with the basic controls for personal characteristics, age and gender, plus country and year fixed effects.[6] As mentioned, the estimates are weighted to account for the survey design, the oversampling of workers in smaller countries.[7] The first column demonstrates a sizeable and statistically significant relationship between piece rate receipt and the incidence of workplace injuries. Workers on piece rates were over 5 percentage points more likely to suffer at least one workplace injury. This is a very large marginal effect as the mean of the dependent variable is only 0.084. The positive and statistically significant relationship with piece rates is not apparent for the other performance pay types, and in fact profit shares are associated with a lower injury incidence perhaps reflecting the type of positions likely to receive profit sharing.

INSERT TABLE 2

The likelihood that piece rates will influence injury risk surely varies by the broad type of job. Commissions for sales people are far less likely to increase injuries than are production based pay for coal miners or factory operatives. We explore this broad conjecture by making a distinction between manual and non-manual occupations. Columns 2 and 3 of Table 2 report estimates of workplace injury incidence split by these occupational groups. Manual workers on piece rates have an incidence of injury of nearly seven percentage points higher than workers without performance related pay. The estimate easily clears all standard tests of statistical significance. The corresponding figure for non-manual workers is only 1.4 percentage points, although this is still statistically significant at the five percent level. Interestingly, there is weak evidence that group bonuses may be associated with higher rates of injury for manual workers. To the extent that such bonuses are related to production or speed, this might be sensible but, as will be shown, this relationship is never statistically significant in the subsequent estimates. In the remaining estimates we concentrate on manual workers. We do so because injuries are concentrated among manual workers and because of the expectation that it is in these occupations that the role of piece rates on injury should be expected.

The estimates in Table 2 ignore work-related characteristics that are likely to influence the incidence of workplace injury and may be associated with payment method. In the first column of Table 3 we add standard workplace controls including hours of work, tenure, four occupational dummies within the manual category and 11 industry dummies. These additions cause a slight reduction in the magnitude of the relationship between piece rates and workplace injuries, but it still remains sizeable (over five percentage points) and statistically significant at the 1 percent level. While the industrial classification system changed between our two waves forcing us to use more aggregated controls, the estimate remains significant and roughly of the same magnitude if we limit ourselves to the 2005 wave and include all 58 available industry dummies.

INSERT TABLE 3

In the second column we add measures of effort to the earlier specification including working at high speed and how many days the respondent worked more than 10 hours in the last month. Both increase the risk of workplace injury, and quite markedly in the case of work speed. However, there is very little change in the piece rate effect on work injury.

Work speed may not be at the discretion of the worker. While speed may be associated with injury regardless of discretion, the critical point about piece rates is that they are sensible only when such discretion exists. The EWCS contains a question asking the worker whether their speed of work was their choice. The last column in Table 3 introduces this as a control and also interacts this with speed of work. Once these controls are added, working at high speed is associated with an even higher risk of injury, about eight percentage points. The variable on ability to choose one's own pace also takes a positive and significant coefficient while the interaction takes a negative coefficient. While the pattern of coefficients is not particularly informative, the critical point is that including the new variables do not change the role of piece rates. Thus, while piece rates are associated with substantially higher injury rates, it does not appear that this works only through a simple decision to work faster or longer.

INSERT TABLE 4

In Table 4 we exploit the richness of the workplace characteristics contained in the EWCS. We first add controls for task types that are likely to influence the incidence of injury and also correlate with the use of piece rates. The first column shows that both monotonous and repetitive tasks take positive but not significant coefficients. Next, we include risk factors and hazards likely to increase the probability of workplace injury. All of the coefficients for the nine hazards take positive signs and six are significantly different from zero. Carrying heavy loads, working in tiring positions and exposure to cold and smoke all take large marginal effects. Despite the importance of the job hazards, the point estimate on piece rates stands essentially unchanged. Thus, the estimates from Table 4 suggest that the increased likelihood of workplace injury associated with piece rates does not flow primarily from the fact that piece rate jobs happen to be those with worse working conditions.[8]

INSERT TABLE 5

In Table 5 we investigate the apparent role of piece rates in two robustness checks. First, we estimate models separately for males and females. These estimates, again for manual workers, are reported in the top panel of Table 5. The estimates reveal a larger piece rate coefficient for males rather than females. In the most complete estimates males on piece rates emerge 6.8 percentage points more likely to be injured. Women on piece rates are only 4.6 percentage points more likely to be injured. Nonetheless, the estimates are statistically significant for both genders. Second, we present estimates for specific forms of workplace injury. We examine whether or not the worker in the last year has had an injury to vision, hearing, the back or muscles. Using the most complete specification and again combining genders, piece rates take a significant positive coefficient for all four types of injury. Importantly, the size of the effect of piece rates appears larger for muscular and back injuries. This would be sensible if the piece rate variable were highlighting a relationship with worker effort levels, rather than workplace hazards.

5.1 Heterogeneity

While we include a full set of country fixed effects and routinely use the sampling weights (which correct for the over-sampling of smaller countries), estimates across countries can remain problematic. The critical country-specific influence may not be a fixed shift but a variation in the parameter of interest, the influence of piece rates. While our sample size does not allow separate estimates within each country, we recognize the substantial differences in social regulations across the countries that could be important and influence the estimates. The two primary social regulations of concern are cross-country differences in sick pay legislation and in workplace health and safety regulations. While more generous sick pay has been routinely associated with greater absence (see, for example, Neuhauser and Raphael 2004), its relationship with actual injury and health is far less clear. This latter relationship relies upon workers taking greater risks at work (engaging in moral hazard) knowing that their time away from work due to injury or poor health will be compensated. In their natural experiment observing exogenous changes in sick pay, Puhani and Sonderhof (2010) confirm the positive association between sick pay generosity and absence but find only modest evidence of an association with medical expenses and no evidence of a relationship between sick pay generosity and actual health. As a consequence, they conclude that more generous sick pay policy is associated with "greater worker absence, modestly greater utilization of health care but no influence on health." To the extent that such results generalize, they suggest that cross-country differences in sick pay may influence absence but not the injury rate reported to researchers.

Health and safety regulation provide the second across-country policy difference that may likely play a role. More strict regulation may reduce accidents and injury but this would be captured in our country fixed effects. Of more concern is that more strict regulations may change the relationship between piece rates and injury. While the *a priori* direction of such a change is unclear, we note that Cottini and Lucifora (2010 p. 27) suggest that health and safety regulation, like labor market regulation more generally, follows broad patterns within Europe. We use this point to divide the sample by groups of countries to test for possible heterogeneity in the influence of piece rates on injury. Specifically, we estimated separate regressions analogous to those in the last column of Table 4 for the set of countries in the EU, the set of countries outside the EU, the set of larger countries (excluding Malta, Cyprus, Slovakia, Slovenia, Lativa, Lituania and Luxembourg), the set of Mediterranean countries, the set of non-Mediterranean countries and the set of Northern European countries (Scandinavia, UK, Germany and Lowlands). While each of these estimates is available from the authors, they are remarkably robust. Each provides a statistically significant positive coefficient on piece rates in the injury equation. Five of the six estimates are in the range from .045 to .060 with only that for the Mediterranean countries somewhat smaller at .038. In short, we find no evidence of substantial heterogeneity by group of countries.

As a further note, we have attempted to cluster errors in various fashions including by country and by country and year. We have no strong *a priori* belief about the appropriate nature of clustering but can report that neither of these experiments materially changed the precision of our piece rate estimate relative to simply using robust standard errors.

Finally, we found somewhat more heterogeneity across industries but nothing that causes us to question our central results. Again, we do not have the sample size to provide separate estimates within each detailed industry but can point to patterns across broad industrial groups. To summarize these we estimated a single regression analogous to that in the final column of Table 4 but which included interactions to account for seven broad industrial groups within the sample of manual workers. No statistically different coefficients on piece rates could be identified for primary industries, manufacturing, transportation or utilities/construction. In each of these cases, the coefficient is roughly that reported in Table 4 or slightly larger. While these four groups represent the majority of piece rate workers, the three remaining industries showed somewhat different coefficients for the influence of piece rates. Mining returned a positive point estimate for piece rates more than twice as large as that indicated in the four industrial groups identified above but it was measured with sufficient imprecision that it was not statistically different than those four. The coefficients for both services and repairs were smaller than those in the four industrial groups identified above and were significantly smaller at 10 percent levels but not five percent level. For all industrial groups the coefficient on piece rates remains positive and is significantly greater than zero in all but the last two groups. This confirms modest heterogeneity by industry in roughly the way that would be anticipated. Piece rates in services are likely to include sales workers, phone center workers and others for whom the risk of injury is simply less likely to vary dramatically because of piece rates or any other reason.

5.2 Endogeneity

We now estimate the bivariate recursive probit outlined earlier. Our identification strategy exploits the well-known link between the adoption of piece rates and the use of quality standards. Piece rates encourage workers to skimp on quality in order to increase the number of pieces. As a result, firms that maintain piece rate systems have a strong incentive to adopt stringent quality standards (Freeman and Kleiner, 2005). For example, fruit pickers are paid only for fruit of a certain size and color that is not bruised (Bandiera et al. 2009, p. 1055). More broadly, Brown (1990) argues that the fear of diminished quality implies that piece rates will only be used in those situations in which precise quality standards can be established and easily monitored. His empirical results strongly confirm that US workers in jobs that require workers to meet "precise limits, tolerances or standards" are far more likely to be paid by the piece. More recently, Bojilov (2010) describes the common practice of US call centers that pay piece rates to workers who resolve claims or collect debts. Part of the practice makes the piece rate payments contingent on a randomly monitored share of calls meeting a quality standard based on easily observed phone etiquette. Thus, when quality is easily measured and precise standards easily enforced, piece rates follow naturally. Piece rates become unlikely when quality is important but is hard to measure, observe or enforce. Yet, these are the circumstances in which precise quality standards are unlikely (again, see Brown 1990). In the EWCS the following question is asked, “Does your main paid job involve meeting precise quality standards?” From the response to this we create a binary indicator that should be linked strongly with receiving piece rates.

INSERT TABLE 6

Table 6 provides estimates of the recursive bivariate probit of piece rates and injury, where for brevity we report only the estimates for the payment methods and the instrumental variable. Quality standards emerge as an important predictor of the use of piece rates as shown in the first column.[9] Other performance pay methods tend to be positively associated with the use of piece rates while the Wald test rejects the assumption of exogeneity. Critically, piece rates retain a positively signed and highly significant coefficient in the estimate of workplace injury. These are average effects and hence difficult to interpret. We computed an Average Treatment Effect on the Treated indicating a 23.9 percentage increase of injury for those individuals on piece rates who were 'treated' by the instruments. Thus, at first appearance this check suggests that the association between piece rates on injury is not being driven purely by endogeneity bias.

While the relevance of the instrument does not seem at issue, its validity (the assumption that it is uncorrelated with injury) is difficult to assess. While including the quality standard indicator in the probit estimation of injury yields a small coefficient far from statistical significance, there is obviously no over-identification test with only one instrument. Moreover, we are unaware of any over-identification test associated with the type of weighted recursive bivariate probit estimated in Table 6. Thus, as a further investigation, we assume a fully linearized version of the estimation ignoring the dichotomous nature of both the dependant variable and the instrument (see Wooldridge 2002). In order to perform an over-identification test, we add the two indicators of task type, repetitive actions and monotony, to the quality standard indicator. Both theory and past evidence makes clear that easily defined and routine tasks tend to be more likely paid by the piece (Parent 2002), and we remove these from the injury equation as their coefficients never approached statistical significance in any of our previous estimations. We use of the ivreg2 command available in STATA 11 (see Baum 2006, p. 194) so as to retain sample weights and robust standard errors. In all other ways, the specification mimics that in Table 6.

Adding the additional instruments, repetitive actions and monotony, created modest attenuation in strength of the instruments but the F-test remained 14.74 again indicating relevance. The Hansen *J* statistic for over-identification emerges as 1.13 (p-value of 0.56) failing to reject over-identification and suggesting validity. Moving this specification (with the three instruments) back to the recursive bivariate probit generates a virtually unchanged coefficient on piece rates of 1.13 that remains highly significant as shown in the second estimation in Table 6. Thus, while our specification requirements do not allow the most straightforward of tests, we continue to find no evidence that endogeneity bias drives the relationship between piece rates and injury.

Establishing relevant comparison groups provides an alternative method to focus on whether or not piece rates genuinely influence behavior. In particular, we identify two sets of workers whose jobs differ in the extent to which worker can respond to piece rate incentives. If the positive correlation between piece rates and injury in the group with greater ability to respond exceeds that with less ability, the likelihood of a genuine influence increases. We use two variables to identify workers with greater ability to respond. We take the worker to have greater ability if they answer positively that they can set their own pace of work and they answer positively that they can organize the order of their tasks. We then reproduce our critical estimate in the last column of Table 4 separately for those who answer positively to both questions positively and for those that do not. The piece rate coefficient for the first group indicates 8.13 percentage points higher risk of injury associated with piece rates while that for the second group indicates only 4.20 percentage points higher risk of injury associated with piece rates. While each coefficient is significantly different from zero, the difference in the two estimates is also significantly different from zero in a fully stacked estimation. Thus, the difference in risk of injury associated with piece rates is twice as large in the group with greater ability to respond to the incentives created by piece rates. This difference supports our instrumental variable estimation in suggesting a genuine influence of piece rates on behavior.

6 Implications

The conjecture borrowed from Adam Smith that piece rates may be uniquely associated with injury and illness has motivated this study. Confirming such an association is important because while a long string of research demonstrates that piece rates increase productivity, recent work has increasingly suggested a series of unintended consequences that reduce profitability. Increased injury risk and the resulting costs have been pointed to as one of those unintended consequences. To the extent that we have confirmed an association in the previous section, it is important not only in its own right but also because it may imply that a portion of the return to piece rates may represent a compensating differential. In this section we briefly discuss evidence on this implication that is, admittedly, more oblique than we would like.

It is necessarily oblique because of the poor quality of the earnings data in the EWCS. They are not consistent across waves and even at its best are only provided in bands made somewhat problematic because of multiple currencies and costs of livings across countries. The best earnings data are from the 2005 wave in which each worker reports the average monthly earnings from their job. These are coded into one of ten bands harmonized across countries emerging roughly as deciles within country. While imperfect, we use this relative earnings measure (ranging from 1 to 10) as a dependent variable in a series of log wage estimates summarized in Appendix Table A2. The fundamental result from the estimates is a robust and large association indicating that piece rates are associated with earnings approximately .4 to .5 higher in the ten point relative earnings measure.[10] Thus, as best as our imperfect earnings measure allows, the results fit the expectation that piece rates are associated with greater earnings, *ceteris paribus*.

It might be tempting to use the injury variable to directly test for compensating differentials and then determine how piece rates moderate such a test. Yet, this proves uninformative as the variable measures an actual injury sustained by a worker rather than the risk of injury associated with a worker's job or detailed occupation. It is latter which is the typical variable used in the compensating differential literature (Black and Kneisser 2003). Actual injuries and the associated lost work time and disabilities are well recognized to be associated with reduced earnings (Boden and Galizzi 2003; Crichton et al. 2005) making it impossible to uncover a positive compensating differential. Thus, estimating a compensating differential with this data is hobbled by both the very coarse earnings measure and the absence of outside evidence on risk of injury by the job. Finally, it is also hampered by the absence of key identifying variables such as wealth and non-labor earnings critical for controlling for income effects that tend to suggest that those with high incomes buy more of all on-the-job amenities including reduced injury risk (see Viscusi 1978).

In the end, we cannot offer evidence on the implication that the return to piece rates may represent, in part, a compensating differential for increase chance of injury. We have shown that our data follows the large literature confirming the return to piece rates, and we have shown that those piece rates are associated with a higher chance of injury. Superior data will be required for a proper test of the interaction between piece rates, injuries and compensating differentials.

7 Conclusion

We have presented a wide variety of estimations using the European Working Conditions Survey to explore a link identified by Adam Smith. The notion was that the incentive to produce more created by piece rates would cause workers to increase the risk of injury. We show that piece rate workers have substantially higher risk of injury that cannot be explained by their personal characteristic, the available characteristics of their job or the hazards to which they are exposed. Moreover, the association does not appear to be driven by endogeneity of piece rates.

We show that the risk associated with piece rates is particularly large for manual workers and for men. Further results indicate that injury risk increases with hazards and with job characteristics such as repetition and monotony. Yet, these controls do little to shrink the marginal effect of piece rates. We show the larger marginal effects of piece rates are associated with muscle and back injuries, the type of injuries that might result from intensified work in response to the incentives. Throughout this series of estimates, the marginal effect associated with piece rates is not only statistically significant but large and remarkably robust. It is typically in the neighborhood of 5 to 6 percent, on a manual base of 14.7 percent. Indeed, despite dozens of variables and a long list of statistically significant controls the majority of the difference in mean injury rates associated with piece rates remains. Critically, our attempts to account for endogeneity do not fundamentally alter this result and our effort to divide the sample into relevant comparison groups suggest that the influence of piece rates is greater when workers have greater ability to respond to the incentives they create.

Perhaps most intriguing has been our attempt to control for speed and effort. Our controls are obviously imperfect in that they may not capture all aspects of those concepts and they rely on subjective evaluations. Nonetheless, they play the anticipated role as significant positive determinants of injury. Yet, they do not greatly diminish the importance of piece rates as an independent determinant of injury. The continued strength and robustness of piece rates raises several possibilities. First, while we know that those paid piece rates work faster and longer according to our measures, those measures may not fully pick-up the relevant dimensions of speed and effort. Second, we may have done a reasonable job of picking-up those dimensions but piece rates create incentives along other dimensions that we cannot observed such as reduced breaks or reduced investment in safety and maintenance. These tasks are likely to be unrewarded by piece rates and so adverse specialization moves workers away from them and toward production, and with production, injury.

TABLE 1 Selected Summary Statistics

	All	Non Manual Workers	Manual Workers	Piece Rates	No Piece Rates
Injury	0.084	0.041	0.147	0.144	0.075
Piece Rate	0.133	0.092	0.191		
Profit Share	0.071	0.083	0.054	0.121	0.063
Group Bonus	0.034	0.037	0.027	0.069	0.028
Share Payment	0.017	0.020	0.017	0.029	0.015
Male	0.529	0.404	0.726	0.611	0.517
Age	38.2	38.0	38.6	38.1	38.2
Tenure (years)	8.4	8.2	8.8	8.4	8.4
Hours	39.0	38.0	40.7	41.0	38.7
Agricultural	0.035	0.005	0.059	0.056	0.032
Mining	0.007	0.003	0.013	0.011	0.006
Manufacturing	0.252	0.141	0.430	0.368	0.234
Retail, Trade and Repairs	0.116	0.147	0.063	0.079	0.121
Utilities and Construction	0.132	0.087	0.205	0.174	0.126
Transport and Communications	0.066	0.069	0.059	0.056	0.067
Services	0.411	0.561	0.171	0.276	0.431
Observations	33501	20641	12860	4361	29140

Source: EWCS 2000 &2005.

TABLE 2 Payment Methods and Risk of Injury, Probit Marginal Effects, EWCS 2000 & 2005.

	All	Manual Workers	Non-Manual Workers
Piece Rate	0.052* [0.009]	0.067* [0.017]	0.014** [0.008]
Profit Share	-0.024* [0.007]	-0.014 [0.021]	-0.009 [0.008]
Group Bonus	0.019 [0.022]	0.079 [0.057]	0.007 [0.010]
Share Payment	-0.016 [0.014]	0.010 [0.044]	-0.013 [0.010]
Male	0.060* [0.004]	0.070* [0.011]	0.012** [0.005]
Age	0.0005 [0.002]	0.001 [0.003]	0.001 [0.001]
Age Sqr * 10	-0.0001 [0.0002]	-0.0002 [0.0004]	-0.00018 [0.00013]
Pseudo r^2	0.056	0.039	0.037
Observations	33,501	12,860	20,641

All models include country population weights and country and year fixed effects. Marginal effects are presented and asymptotic standard errors are in parentheses with *,** and *** indicating statistical significance at the 1%, 5% and 10% level, respectively.

TABLE 3 Payment Methods and Risk of Injury, Manual Workers, Probit Marginal Effects

	II + Work Characteristics	**III** Effort	**IIIb** Effort and Discretion
Piece Rate	0.063*[0.017]	0.055*[0.016]	0.054* [0.016]
Profit Share	-0.014 [0.021]	-0.015 [0.021]	-0.016 [0.020]
Group Bonus	0.068 [0.054]	0.064 [0.052]	0.059 [0.051]
Share Payment	0.024 [0.048]	0.034 [0.051]	0.034 [0.053]
Male	0.049*[0.013]	0.053* [0.012]	0.052* [0.012]
Age	0.001 [0.003]	0.0001[0.003]	0.0002[0.0003]
Age^2*10	-0.001[0.001]	-0.0002[0.0004]	-0.0002[0.0004]
Tenure	0.001[0.001]	0.001[0.001]	0.001 [0.001]
Hours	0.002*[0.001]	0.0014**[0.0007]	0.002* [0.001]
High Speed		0.056* [0.011]	0.084* [0.017]
Work Long Hours		0.002** [0.001]	
Choose Own Work Rate			0.043* [0.014]
Choose * High Speed			-0.038***[0.019]
Occupational Controls	✓	✓	✓
Industry Controls	✓	✓	✓
Pseudo r^2	0.057	0.066	0.067
Observations	12,860		

All models include country population weights and country and year fixed effects. Marginal effects are presented and asymptotic standard errors are in parentheses with *,** and *** indicating statistical significance at the 1%, 5% and 10% level, respectively.

TABLE 4 Payment Methods and Workplace Hazards, Manual Workers,

Probit Marginal Effects

	III + Task Type	+ Work Hazards
Piece Rate	0.052* [0.016]	0.057* [0.015]
Profit Share	-0.015 [0.021]	-0.020 [0.019]
Group Bonus	0.064 [0.052]	0.052 [0.050]
Share Payment	0.033 [0.050]	0.042 [0.042]
Male	0.054* [0.012]	0.030* [0.013]
Task Type:		
Monotonous	0.013 [0.010]	-0.004 [0.010]
Repetitive Actions	0.013 [0.010]	-0.002 [0.009]
Work Hazards:		
Exposure to Vibrations		0.001 [0.002]
Noise		0.009* [0.003]
High Temperatures		0.002 [0.002]
Low Temperatures		0.012* [0.003]
Smoke/Fumes		0.013* [0.003]
Chemicals		0.001 [0.002]
Radiation		0.008** [0.004]
Tiring Positions		0.012* [0.003]
Heavy Loads		0.016* [0.003]
Occupational Controls	✓	✓
Industry Controls	✓	✓
Pseudo r^2	0.067	0.150
Observations	12,860	12,860

All models include country population weights and country and year fixed effects. Marginal effects are presented and asymptotic standard errors are in parentheses with *,** and *** indicating statistical significance at the 1%, 5% and 10% level, respectively.

TABLE 5 Piece Rates and Workplace Injury by Gender and Type of Injury, Manual Workers, Probit Marginal Effects.

	II		III + Workplace Hazards	
	Male	*Female*	*Male*	*Female*
Piece Rate	0.075*	0.049*	0.068*	0.046**
	[0.020]	[0.021]	[0.019]	[0.020]
Pseudo r^2	0.057	0.070	0.161	0.120
Obs	9,331	3,454	9,331	3,454

Types of Injury (Model III + Workplace Hazards)

	Hearing	*Vision*	*Back*	*Muscle*
Piece Rate	0.032*	0.030*	0.058*	0.062*
	[0.013]	[0.011]	[0.022]	[0.022]
Pseudo r^2	0.238	0.178	0.174	0.172
Observations	12,860			

All models include country population weights and country and year fixed effects. Marginal effects are presented and asymptotic standard errors are in parentheses with *,** and *** indicating statistical significance at the 1%, 5% and 10% level, respectively.

TABLE 6 Piece Rates and Workplace Injury, Recursive Bivariate Probit (Average Effects)

	Piece Rate	*Injury*	*Piece Rate*	*Injury*
Piece Rate		1.075*		1.139*
		[0.410]		[0.435]
Profit Share	0.290*	-0.153	0.291*	-0.154
	[0.101]	[0.111]	[0.101]	[0.106]
Group Bonus	0.198	0.174	0.194	0.171
	[0.150]	[0.210]	[0.155]	[0.04]
Share Payment	0.245	0.145	0.215	0.173
	[0.199]	[0.154]	[0.193]	[0.152]
Quality Standards	0.212*		0.269*	
	[0.062]		[0.063]	
Repetitive Actions			0.218*	
			[0.487]	
Monotonous			0.079	
			[0.053]	
rho (ρ)	-0.449**		-0.486**	
	[0.216]		[0.227]	
Obs	12,860		12,860	

Model includes country population weights and country and year fixed effects. All other controls are included as per the final column of Table 3. Asymptotic standard errors are in parentheses with *,** and *** indicating statistical significance at the 1%, 5% and 10% level, respectively.

REFERENCES

Bandiera, O, Barankay I, Rasul I (2009) Social Connections and Incentives in the Workplace: Evidence form Personnel Data. *Econometrica* 77(4): 1047 – 1094

Banker RD, Field, JM Schroeder RG Sinha KK (1996) Impact of Work Teams on Manufacturing Performance: A Field Study. *Academy of Management Journal* 39(4): 867 – 890

Baum CF (2006) *An Introduction to Modern Econometrics Using Stata*. Stata Press: College Station Texas

Belman DL, Monaco KA, Brooks TJ (2005) *Sailors of the Concrete Sea: A Portrait of Truck Drivers' Work and Lives*. Michigan State University Press: East Lansing Michigan

Black DA, Kneisser TJ (2003) On the Measurement of Job Risk in Hedonic Wage Models. *Journal of Risk and Uncertainty* 27(3): 205 – 220

Boden L, Galizzi M (2003) Income Losses of Women and Men Injured at Work. *Journal of Human Resources*, 38(3): 727 – 757

Bojilov R (2010) Estimating the Effect of Incentives when Workers Learn about their Abilities. Working Paper, Columbia University, Department of Economics. November 21, 2010

Booth AL, Frank J (1999) Earnings, Productivity, and Performance-Related Pay. *Journal of Labor Economics* 17(3): 447 – 463

Brown C (1990) Firms' Choice of Method of Pay. *Industrial and Labor Relations Review* 43(s): 165s – 82s

Cornellissen T, Heywood JS, Jirjahn U (2011) Performance Pay, Risk Attitudes and Job Satisfaction. *Labour Economics* 18(2): 229 – 239

Cottini E, Lorifora C (2010) Mental Health and Working Conditions in European Countries. *IZA Discussion Paper*, No. 4717

Creighton S, Stillman S, Hyslop D (2011) Returning to Work from Injury: Longitudinal

Evidence on Employment and Earnings. *Industrial and Labor Relations Review* 64(4): 765 - 785

Curme M, Stefanec N (2007) Worker Quality and Labor Market Sorting. *Economics Letters* 96(2): 202 – 208.

Dale-Olsen H (2006) Estimating Workers' Marginal Willingness to Pay for Safety using Linked Employer–Employee Data. *Economica* 73(294): 99 – 127.

Foster AD, Rosenzweig, MR (1994) A Test for Moral Hazard in the Labor Market: Contractual Arrangements, Effort, and Health. *Review of Economics and Statistics* 74(2): 213 - 227

Freeman RD, Kleiner M (2005) The Last American Shoe Manufactures: Decreasing Productivity and Increasing Profits in a Shift from Piece Rates to Continuous Flow Production. *Industrial Relations* 44(2): 307 – 330.

Frick B, Gotzen U, Simmons R (2008) The Hidden Costs of High Performance Work Practices: Evidence form a Large German Steel Company. Working Paper, Department of Management, University of Paderborn, Germany.

Garen J (1988) Compensating Wage Differentials and the Endogeneity of Job Riskiness. *Review of Economics and Statistics* 70(1): 9 – 16

Gibbons R (1998) Incentives and Careers in Organizations. *Journal of Economic Perspectives* 12(4): 115 – 132

Gielen AC, Kerkhofs MJM, van Ours, JC (2010) How Performance Related Pay Affects Productivity and Employment. *Journal of Population Economics* 23(4): 291 - 301

Green CP, Heywood JS (2008) Does Performance Pay Increase Job Satisfaction? *Economica* 75(300): 710 – 728

Haley MR (2003) The Response of Worker Effort to Piece Rates: Evidence from the Midwest Logging Industry. *Journal of Human Resources* 38(4): 225 – 249

Heckman, JJ (1978) Dummy Endogenous Variables in a Simultaneous Equation System. *Econometrica* 46(4): 931 – 959

Holmstrom B, Milgrom P (1987) Aggregation and Linearity in the Provision of Intertemporal Incentives. *Econometrica* 55(2): 303 – 328

Jones D, Kalmi P, Kauhanen, A (2010) Teams, Performance-Related Pay, Profit-Sharing and Productive Efficiency: Evidence from a Food-Processing Plant. *Industrial and Labor Relations Review* 63(4): 606 - 626

Korn EL, Graubard BI (1990) Simultaneous Testing of Regression Coefficients with Complex Survey Data: Use of Benferroni *t*-Statistics. *The American Statistician* 44(4): 270 – 276

Lazear EP (2000) Performance Pay and Productivity. *American Economic Review* 90(5): 1346 – 1361

Lazear EP (1986) Salaries and Piece Rates. *Journal of Business* 59(3): 405 - 431

MacDonald G, Marx LM (2001) Adverse Specialization. *Journal of Political Economy* 109(4): 864 – 899

Maddala GS (1983) *Limited-Dependent and Qualitative Variables in Economics*. Cambridge University Press: New York.

Monaco K, Williams, E (2000) Assessing the Determinants of Safety in the Trucking Industry. *Journal of Transportation and Statistics* 3(2): 69 – 80

Monfardini C, Radice R (2008) Testing Exogeneity in the Bivariate Probit Model: A Monte Carlo Study. *Oxford Bulletin of Economics and Statistics* 70(2): 271-282

Neuhauser F,. Raphael S (2004) The Effect of an Increase in Workers Compensation on the Duration and Frequency of Benefit Receipt. *Review of Economics and Statistics* 86(1): 288 – 302

Parent D (2002) Performance Pay in the United States: Its Determinants and Effects. In Brown

M, Heywood JS (eds) *Paying for Performance: An International Comparison*. M.E Sharpe Publishers: Armonk NY

Parent D. (1999) Methods of Pay and Earnings: A Longitudinal Analysis. *Industrial and Labor Relations Review* 53(1): 71 – 86

Pekkarinen T, Riddell C (2008) Performance Pay and Earnings: Evidence from Personnel Records. *Industrial and Labor Relations Review* 61(3): 297 - 319

Puhani PA Sonderhof K (2010) The Effects of Sick Pay Reform on Absence and Health Outcomes. *Journal of Health Economics* 29(2): 285 - 302

Rodriquez DA, Targa, F Belzer, M (2006) Pay Incentives and Truck Driver Safety: a Case Study. *Industrial and Labor Relations Review* 59(2): 205 – 225

Saha A, Tamnath T, Chaudhuri R, Saiyed H (2004) An Accident-Risk Assessment Study of Temporary Piece Rated Workers. *Industrial Health* 42(3): 240 – 45

Seiler E. (1984) Piece Rates vs. Time Rates: The Effect of Incentives on Wages. *Review of Economics and Statistics* 46(3): 363 – 376

Smith A (1776) *An Inquiry into the Nature and Causes of the Wealth of Nations* as reprinted in 1909, edited by CJ Bullock, PF Collier & Son: New York.

Stock JH, Yogo M (2005) Testing for Weak Instruments in Linear IV Regression. In Andrews DWK, Stock, JH (eds) *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*. Cambridge University Press: Cambridge 80–108

Sundstroem-Frisk C (1984) Behavioral Control through Piece-rate Wages. *Journal of Occupational Accidents* 6(1-2): 49-59

Toupin D, LeBel L, Dubeau, D, Imbeau D, Bouthiller L (2007) Measuring the Productivity and Physical Workload of Brushcutters within the Context of a Production-Based Pay System. *Forest*

Policy and Economics 9(8): 1046 – 55

Viscusi WK (1978) Wealth Effects and the Premiums for Job Hazards. *Review of Economics and Statistics* 60(3): 408 – 16

Wilde J (2000) Identification of Multiple Equation Probit Models with Endogenous Dummy Regressors. *Economics Letters* 69(3): 309 - 312

Williamson A, Bohle P, Quinlan M, Kennedy, D (2009) Short Trips and Long Days: Safety and Health in Short-Haul Trucking. *Industrial and Labor Relations Review* 62(3): 415-429

Wooldridge J (2002) *Econometric Analysis of Cross-Section and Panel Data*. MIT Press: Cambridge MA.

ENDNOTES

[1] See Dale-Olsen (2006) for a recent confirmation of compensating differentials for injury.

[2] Cornellissen et al. (2010) formally model piece rate workers sorting on two dimensions.

[3] Garen (1988) similarly emphasizes the endogeneity of injury risk arguing that those with largest earnings capacity will avoid the risk as safety is a normal good.

[4] Alternative incentives schemes such as efficiency wages may also attract those with greater inherent productivity but remain time rates. Thus, if injury reflects effort (productivity), our comparison of injury on piece rates and on time rates may be an underestimate as it fails to control for such alternative incentive schemes.

[5] The full list of countries are Belgium, Czech Republic, Denmark, Germany, Estonia, Greece, Spain, France, Ireland, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Bulgaria, Croatia, Romania, Turkey, Norway and Switzerland.

[6] Education is not consistently measured across waves of the EWCS and as a result we do not use it as a control. In unreported but available estimates on the 2005 EWCS the inclusion of education did not substantively change the estimates of piece rates on workplace injury.

[7] It is worth noting however that the sign and significance of all piece rate estimates presented in this paper are robust to unweighted estimation.

[8] The large significant coefficient remained when we again limited the sample to only 2005 and included the full 58 industrial dummies.

[9] Indeed, a linear probability version of the model in Table 6 yields test statistics that are above the critical values outlined by Stock and Yogo (2005) to detect weak instruments (F-Test = 26.770).

[10] Similar magnitudes emerge from ordered probit estimates available from the authors.