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DOES EMPLOYER MONOPSONY POWER INCREASE OCCUPATIONAL ACCIDENTS? THE CASE OF KENTUCKY COAL MINES

Shulamit Kahn

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ABSTRACT

A popular argument for safety regulations is that workers accept dangerous jobs because they have "no choice," or, in other words, because they have few or no alternative employment opportunities. This argument is considered in a game-theoretic framework. Because simultaneous-entry models do not yield pure-strategy equilibria, this paper develops a sequential-entry model to analyze the effect of additional firms on occupational safety. Within the context of the particular functional specification modeled, additional firms (except for the second entrant) lower average accident rates and thus increase occupational safety, consistent with the popular argument. However, with other functional specifications, the model could yield different results.

As a result, the paper continues with an empirical investigation of the effect of monopsony power for a particular labor market -- nonunionized Kentucky coal mines in the later 70s -- a labor market which is likely to be particularly susceptible to monopsony. The empirical work shows that areas with many choices of alternative employers within easy driving distance do have lower accident rates. For this labor market, at least, when more alternative choices in the same occupation are offered, average occupational safety levels increase. Policies that improve occupational mobility and the competitiveness of labor markets, therefore, may simultaneously improve occupational safety.

Shulamit Kahn
Department of Finance
and Economics
Boston University
School of Management
704 Commonwealth Avenue
Boston, MA 02215
and NBER

A popular argument for safety regulations is that workers accept dangerous jobs because they have "no choice", or, in other words, because they have few or no alternative employment opportunities. However, I argue in Section I that the effect of monopsony on occupational safety is theoretically indeterminate. Therefore, I investigate the issue empirically by considering a cross-section of nonunionized Kentucky coal mines in the later 70's, a labor market which is likely to be particularly susceptible to monopsony. The empirical work shows that areas with many choices of alternative employers have lower accident rates. In the final section, I consider the implications of this finding for regulation.

I. Theoretical Background

There are two conceptually different approaches to modelling the effect of monopsony power on occupational safety or the analogous monopoly effect on product quality. (Since the problems are isomorphic, in the following literature review, for expositional clarity I will couch all discussion in terms of the job safety case, although most articles, in fact, deal with product quality.) The first concentrates on the fact that monopsonies restrict labor demand, moving down the labor supply curve, in order to decrease compensation. Viscusi (1980) models the effect of monopsony on occupational safety in this way, basing his analysis on the product monopoly case analyzed in Spence, 1975[1]. In this literature, all decisions even in the competitive case are modeled as being made by a single firm and hence offering a single quality or safety level.[2] The effects of labor

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[1]See also Levhari and Peles, 1973; Schmalensee, 1979 on the product market case. On the effect of monopsony on occupational safety, see also Smith, 1976 and Dickens 1983 for a review.

[2]Perfectly competitive firms are differentiated from monopsonistic firms by their infinite elasticity of labor supply and the zero profit condition.

contraction by monopsonies on this single safety level is ambiguous and depends on the preferences of the inframarginal versus the marginal workers, i.e. the worker who would leave if compensation decreased slightly. Smith (1976) and Viscusi (1980) assume that marginal workers are the young workers who, they hypothesize, prefer safety less than older, inframarginal workers. If this is true, labor contraction by monopsony would increase occupational safety. However, for all U.S. nonunion manufacturing, Kahn (1987) finds that in 1978, lower tenure workers, with their lower age and different demographic characteristics, tended to prefer more safety (relative to wages), not less.[3]

The Spence/Viscusi single-safety-level approach ignores the possibility of a variety of occupational safety levels being offered simultaneously by different firms in competitive markets. It is strictly applicable only in cases where technological considerations require that all existing firms choose to set a common safety level.

A more realistic approach, and that adopted here, is to acknowledge the variety of safety levels offered in non-monopsonistic settings.[4] As Rosen (1974) and Thaler and Rosen (1975) point out, perfect competition is characterized by a continuum of wage/safety choices along a market equilibrium hedonic locus. Workers can choose the level of safety they desire, sorting themselves by preferences. In this framework, there are no inframarginal workers and the market

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[3]Moreover, the marginal workers may not be the younger workers, as pointed out by Dickens (1983). In the case of mining, the marginal worker might be anyone with high preferences for safety, insofar as their concern about safety makes them hesitant to enter or stay in mining.

[4]In the following discussion, following the literature, I assume for expositional simplicity that each firm sets a single safety and wage level.

is efficient.[5] In contrast, as a market becomes more monopsonistic, the number of firms hiring in a labor market decreases and the number of safety/wage choices similarly decreases. (Since there is no single safety level, to measure the effect of limiting choices on safety, we look at its impact on average safety, and perhaps on the range of safety levels offered as well.) If the market collapses to a single firm, the safety level this firm sets will not be in the middle of the range offered in a competitive market hiring the same number of workers, but rather at the safety level desired by the marginal worker it employed. If the single firm hires considerably fewer than those employed in competition, the identity of the marginal worker changes and this further changes the safety offered in monopsony.

Most labor markets exhibit neither extreme -- perfect competition with infinite firms or perfect monopsony. For any but the extremes, the effect of more choices must be considered within a game-theoretic framework. The particular framework that I present below models firms' decisions as occurring in stages. Safety is set prior to wage. Wages are set at the Nash equilibrium levels. The firm's level of safety is modeled as a once-and-for all decision, and entry of firms occurs sequentially. The number of firms that enter can either be set exogenously or determined endogenously given fixed costs of operation.

This model of safety/wage setting in a multifirm context has several attractive features that make it relatively well suited to modelling occupational safety, particularly in the case of coal mining. Entry of mines is sequential, and many aspects of occupational safety require large investments that cannot be easily changed. Furthermore, firms may gain reputations about their safety that

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[5]Spence's (1975) single competitive firm has inframarginal workers and therefore the amount of quality provided is not optimal.

are not easily altered; and once they have attracted workers who prefer their safety offer, any change in their safety might entail costly worker turnover.[6]

A second advantage of this sequential entry model is that generally pure strategy equilibria exist for these kinds of models. In contrast, game-theoretic oligopoly models where safety and wage are chosen simultaneously generally have no pure-strategy Nash equilibria solutions,[7] limiting their appeal. The nonexistence of a pure-strategy equilibrium is a frequent problem when payoff functions are discontinuous (and quasiconcave), as they are here since there is a sharp difference in firms' profits between the case where two firms locate at exactly the same wage/safety compared to the case where two firms locate at slightly different wages and safety. The likelihood of an equilibrium is increased if the decision-making is separated into a two-stage process, where safety is set prior to wage.[8] Once safety levels are set, a pure-strategy Nash equilibrium in wages

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[6]One less suitable aspect of these models is that in actuality often the scale of the mining is determined solely by technological considerations and not (at the margin) affected by the availability of labor as in the models. Another is that it is very possible that mining operators do not always accurately predict how many additional entrants there will be.

[7] To demonstrate why this is true intuitively, consider the two firm game where each firm simultaneously chooses safety and wage and there are constant returns to scale. No situation with unequal profits can be a Nash equilibrium: a) if firm A is making more profits than B, B can always position itself arbitrarily close to A with an epsilon more attractive offer in both safety and wages and attract all of A's previous market; b) if both A and B are making equal positive profits per worker, they are both positioned along a concave isocost curve (per worker) in safety-wage space. However, each can always increase its profits (assuming the other remains at its current safety/wage combination) by moving its safety/wage combination along the isocost curve in the direction of its competitor's, thereby attracting workers from them and making more total profits. c) If both A and B are each making zero profits (i.e. are positioned along the zero profit isocost curve) each could get a positive profit by moving to a slightly lower isocost curve via a decrease in safety or wage that maintains a sufficiently higher safety or wage to be attractive to at least one worker, thereby earning positive profits given the lower cost.

[8]Other models that could be considered include ones where the firm sets safety and employment, rather than safety and wages.

can generally be identified (e.g. Lane, 1980; Shaked and Sutton, 1982).[9] At the safety setting stage, however, although there are specific cases where a pure strategy equilibrium exists[10] (for example, see Shaked and Sutton 1982), there will often be no pure strategy equilibrium (for example, see Prescott and Visscher, 1977, p.387).[11]

The sequential entry model has been used by several authors for the product quality case. Prescott and Visscher, 1977 (P&V) and Lane, 1980 develop sequential product quality (vertical product differentiation) models for two different preference and cost frameworks;[12] both also make the simplifying (and unrealistic) assumption that consumer demand is exogenous, equivalent in the job quality case to exogenous labor supply where all workers work in all situations. These sequential models typically have no analytic solutions; both authors therefore characterize the resulting equilibrium by using numerical simulations. The basic conclusions of both P&V and Lane are identical (and many of these conclusions are shared by the analytic model of Shaked and Sutton, 1982 which does

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[9]Note again that this literature was developed in terms of the product quality case; for clarity of exposition, I present it in terms of the analogous job safety case.

[10]i.e. a subgame perfect pure strategy Nash equilibrium in safety exists in the game where outcomes are understood to be the Nash equilibrium of the subsequent wage stage.

[11]Dasgupta and Maskin (1986) prove that there will always be a mixed-strategy equilibrium (at least in the simultaneous wage-quality case) even when payoff functions are discontinuous, as long as certain relatively weak conditions are satisfied (as they are is the simultaneous safety-wage oligopoly problem). However, mixed strategy equilibria do not seem compelling in this context.

[12]In the product market case of P&V, consumers minimize P + v X, where P is price and X is a measure of poor quality (e.g. waiting time). v is distributed uniformly. Firm's costs are c/(c+bX), where c and b are parameters, set to 40 and 1 respectively in their numerical simulation. In Lane, consumers maximize $Q^{a}Z^{1-a}(Y-P)$ where Q and Z are two product characteristics, Y is income. Marginal cost per unit is assumed the same for all levels of product characteristics, an especially limiting assumption.

not require sequential once-and-for-all quality choices): the first entrant firm positions itself at the "best" safety position (e.g. least cost, or most attractive to most workers, which could be at either extreme or in the middle) and makes most profits; subsequent entrants position themselves as far from existing firms as possible without inducing entry at intervening safety levels.[13] They shun closer safety positions because these encourage wage competition and lower all parties' profits. Later entrants typically make less profit (although there are some exceptions). If entry is endogenous, lower fixed costs increases the number of entrants. Even when fixed costs do not fall enough to alter the number of firms, any decrease in fixed costs alters the distribution of safety and wage as firms position themselves more competitively to keep out new entrants.

Examination of the numerical outcomes in P&V and Lane yield very similar conclusions about the range of safety alternatives offered: the more firms, the larger the range of safety extremes offered, with later entrants positioning themselves at more extreme distances from the first entrant. However, conclusions about the average level of safety are entirely dependent on the particular parameters and preference and cost structures assumed, as the authors themselves readily realized.[14] Under different assumptions, more entrants could lead to

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[13]Notwithstanding this general pattern, with differing exogenous numbers of firms, the equilibrium safety/wage of all firms (except at times the first entrant) will differ.

[14]For instance, given the parameters, cost and preference structures assumed in P&V's example, the first entrant chose the minimum quality technically allowed; subsequent entrants chose higher quality levels. Further, the more firms there were, the more extreme the earlier entrants (except the first) set quality. As the number of firms increased, therefore, average quality rose considerably in their example. However, modifications in their cost structure could make it advantageous for the first entrant to offer the highest quality, not the lowest; in this case, an increasing number of firms entails (substantially) lower average safety. In contrast, given Lane's different cost and preference structures, the first firm positioned itself at the middle of the feasible quality range, and entrants, while increasing the range of quality extremes offered, had little

higher, lower or substantially unchanged average safety.

To further investigate the implications of sequential entry models for the relationship between monopsony and occupational safety, I have run simulations of a model of sequential entry. The model used here is very similar to the P&V simulations on product quality. The major departure between the model developed here and P&V's model is that here, I have dropped the unrealistic assumption of an exogenous labor supply (or product demand in P&V) and replaced it with endogenous labor so that workers work only if they can attain at least a minimum utility level. Relaxing this assumption not only makes the model more realistic; it is necessary to fully analyze the effect of monopsony power in these models, since without it there can be no employment restriction effect of monopsony power. Dropping this assumption also enables me to drop the arbitrary limits to the safety range. (This is likely to lead to results very different from P&V, where where firms generally located at the imposed limits.)

Assume that workers' utility is:

(1) $U = W - vA$

where W is wage, A is the accident rate and v is an index that is uniformly distributed between zero and some high bound. Workers work as long as:

(2) $W - v A > K$

where K differs in different simulations. With this utility function, marginal workers prefer low accident rates A in the sense that, for any given wage and accident rate, the workers who do not work will be those with higher v's i.e. those who have a higher marginal rate of substitution dW/dA. Costs of providing safety are X/A, where X is a parameter that differs among specifications. Production is characterized by constant returns per worker. Without loss of

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impact on the mean.

generality, product price is set to equal one. Profits can thus be expressed as:

(3) $\pi = L\ (1 - W - X/A)$

Firms enter the market only if profits will be positive.

Note that the utility function is identical to P&V, except for sign changes required to transform it to a wage/safety rather than consumer price/quality example. The cost function used here is slightly simpler than P&V's, basically because the wage-quality problem allowed this simpler form[15]. In the discussion below, I concentrate on results for average accident rates.

The literature in this area considers two kinds of situations, those where the number of firms is set exogenously and those where the number of firms is determined endogenously. The main difference between the exogenous-firms and the endogenous-firms models is that the latter allows potential entry so that firms position their accident rates and wages to defend against entry. Since we are interested in the effect of the number of firms on the average safety rate, this might suggest a situation where the number of possible firms is exogenously set. On the other hand, an endogenous-firms model is more appropriate in cases where new firms would enter the market if the present firms varied their accident rate or wage. Because the choice is not straightforward, I have developed examples of both situations here.

The sequential entry models of the authors discussed above did not yield to analytical solution, so, similar to them, I have found the (subgame perfect) perfect solutions numerically. In these simulations, the last entrant conducts a grid search over possible safety levels, searching for the one that gives the highest profits given the safety levels set by previous entrants and given the

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[15]Lane and Shaked and Sutton do not have <u>costly</u> product quality, but nevertheless do have vertical differentiation of their product so that everyone prefers higher levels quality to lower ones.

(analytically solved) Nash equilibrium wages. The next to last entrant conducts a grid search over possible safety levels, searching for the one which gives the highest profits given the safety level of previous entrants, the predicted safety choice of the last entrant (which will be contingent on the next to last's safety decision), and of course the Nash equilibrium wages. Etc.

Table 1 gives the results of simulations assuming a variety of different parameter values for when the number of firms is exogenously set at one, two, three and four respectively.[16] Averages given are employment weighted. In these simulations, the results for the different parameters share a single pattern. The average accident rate for two firms is greater than the accident rate with a single firm. However, entrance of a third firm lowers the average accident rate. The entrance of a fourth firm further lowers the average accident rate. Thus, the entrance of a second firm may be qualitatively different from the entrance of further firms.

The effect on average accident rates will be the focus of the empirical work in the second part of this paper. However, there are other aspects of the equilibria -- the range of accident rates, the relative safety choices of the early and late entrants, the employment and profit levels of first and later entrants, etc. -- that cannot be studied empirically with the available data; this theoretical model can shed some light on these issues.

The effect of additional entrants on the range of accident rates is also

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[16]To locate the equilibria, I searched accident rates that varied from a minimum of X plus epsilon, where the per person cost of safety=X/A, to a maximum high enough to lead to internal solutions. (Note that accident rates lower than x would lead to negative profits even with zero wages as the cost of safety would exceed the output value of 1.) It is of course possible that these points are not actually <u>the</u> equilibria, since I have searched only a finite number of points. Note that other parameter values were simulated than the ones presented in the table; all demonstrated the same patterns as those presented.

qualitatively different for the movement from one to two firms than for the movement from two to three or three to four firms. In all cases, as the number of firms increases, the range of accident rates increases as the firms spread themselves out to attract different workers. However, as we move from one to two firms, the two firms both choose higher accident rates than the single firm did. With three firms, on the other hand, the range of accident rates offered expands in both directions from the two-firm range.[17] With four firms, the range expands yet further in both directions. In these simulations, the first entrant always sets the lowest accident rate (highest safety) and later entrants set increasingly higher accident rates. Note that these results are very different from cases where binding arbitrary limits are set on the range of allowable accident rates, as they were in P&V and Lane. In fact, in other simulation runs (available from the author) where binding limits on accident rates are set, this ordering of accident rates is often reversed. Either the first <u>or</u> last entrant locates at the range's limit. Further, the accident rates may have any pattern: monotonically decreasing with the order of entry, monotonically increasing, or nonmonotonic. Thus, this point of departure from P&V, relaxing all arbitrary limits on accident rates by assuming endogenous labor supply, affects the outcomes considerably.

The more firms in the market, the larger the total employment. For instance, the first firm has somewhat less employment in the presence of an additional firm (about 11% less), but the second firm has about 50% of the employment of the first. Thus, the employment restriction effect of monopsony in the standard neoclassical theory carries over to this game-theoretic oligopsony model. The firms are not equally sized: the earlier firms to enter are always

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[17]Thus, the lowest accident rate in the three firm model is lower than the lowest accident rate in the two firm model, while the highest accident rate is higher.

larger in employment. There is also a substantial profit advantage to being an earlier entrant.[18] However, as expected, profits of the early entrants are substantially lower the more firms there are in the market, and total profits earned by all firms together fall rapidly as the number of firm increases. (For instance, for K=.2 and X=.5, total profits with four firms are 11.3 compared to monopoly profits of 37.9.)

In additional simulations, I let the number of firms be endogenous by assuming fixed costs sufficiently high so that at least one potential firm chooses not to enter because they can only obtain negative profits. I also varied the fixed cost to examine the sensitivity of the equilibrium to this parameter. The results are not reported separately in Table 1 because they are identical to the exogenous-firm outcomes: when the fixed cost is set at or slightly above the profit level of the last entrant in an exogenous-firms model, the last entrant does not enter. However, accident rates of the first entrant(s) are kept at the level at which they would be if the additional entrant had found it profitable to enter, in order to prevent further entry. (For instance, when X=.2 and K=.2, the profit level of the third firm without fixed costs was 6.33. If fixed costs are 6.34, the third firm does not find it profitable to enter. However, the first two firms continue to offer accident levels equal to .67 and 1.06 respectively, the levels which they chose when there were three entrants and no fixed costs. Even before subtracting out the fixed cost, they make considerably less profit than they would in an exogenous-two-firm model because they must position themselves

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[18]As noted in the literature, if this were not true, it would be hard to explain how the "equilibrium" is ever reached, since there would be an advantage to staying on the sidelines, waiting for others to enter first.

defensively to keep out the third firm.[19]) The slight increase in fixed costs that causes a firm to drop out of the market leads to lower, not higher, average accident rates since it was the highest accident-rate firm that dropped out while the other two maintained their old accident rate levels.

As fixed costs continue to rise, they provide a larger and larger barrier to entry, and the remaining firms adjust their accident rates and wages towards the more profitable levels that would be set in an exogenous model with the fewer number of firms; the average accident rates therefore increase (except in the case of a single firm). As fixed costs further rise, another entrant drops out of the equilibrium, etc. Thus, if we consider two labor markets with different fixed costs, they will have different average accident rates and different numbers of firms. For some combinations of fixed costs in the two areas, average accident rates will be higher in the market with more firms; for other combinations of fixed costs, average accident rates will be lower in the market with more firms. Only in the case where one market has a single firm and the other market has two, is there an unambiguous prediction, i.e. that the single firm will offer lower safety than the average with more firms.[20]

To recap, with this particular utility curve, the existence of a second firm (either exogenously or due to lower fixed costs) increases the average accident rate compared to a single firm; but existence of a third and a fourth firm (and presumably further entrants as well) lowers average accident rates when the number

[19]Compare profits here of 32.0 and 18.2 for the first and second entrants respectively (before subtracting fixed costs) with profits of 48.4 and 21.5 in the case where there are exogenously two firms.

[20]To see this, note that both firms in a two-firm market offer higher accident rates than in the single firm market. When fixed costs rise to the point that the high-accident firm drops out while the remaining firm keeps its accident rate the same, the new "average" accident rate is considerably lower than with two firms. As fixed costs continue to rise, the single firm's accident rate falls even more.

of firms is set exogenously. However, when the number of firms is set endogenously, no predictions can be made about the impact of increasing numbers of firms on average accident rates that will be true in all circumstances.

While this model gives us a structure within which to think of the possible effect of new entrants, if we were to model utility with a different functional form or if we were to assume different distributions for utility parameters, it seems quite possible that there would be different implications of increasing the number of firms on average accident rates.

In sum, neither of the approaches to monopsonies -- isolating its impact on labor demanded in a single-safety model or extending the analysis to consider monopsony's limits on the number of safety/wage choices -- yields unambiguous effects on average occupational safety. However, both approaches suggest that the number of firms <u>can</u> have important effects on average accident rates, and that the existence of a second firm can have qualitatively different effects than the existence of additional firms. The relationship between the number of firms and average accident rates is therefore an issue that should be subjected to empirical testing. In the remainder of this paper, I consider this relationship for one particular case study.

II. Empirical Measures of Monopsony Power and Their Interpretation

To test the relation between occupational safety and monopsony power, I estimate the effect of monopsony measures on accident rates in nonunion Kentucky coal mining. This specific case was chosen because it is likely to be especially susceptible to monopsony power: Appalachian miners have very specialized skills and also tend to have strong historical ties to the geographic area. Both factors inhibit them from searching for jobs elsewhere and ensure that miners' most highly substitutable jobs are at other nearby mines. The time period chosen, 1971, was early enough that accident rates had been little affected by the increased regulation of safety that followed the passage of the Coal Mine Health and Safety Act of 1969. (Nationally, this law had little or no effect on accident rates in 1970, and only a slight impact by 1971.[21] In Kentucky, revised statutes regarding occupational safety and health were not passed until late 1972.) The early time period also preceded other regulations affecting coal-mining directly or indirectly, including pollution controls on combustion of coal. Some of the data are available only beginning in 1971, which prevented analysis of an earlier time period. Since the theory describes the effect of additional firms in a nonunion environment,[22] the empirical analysis was limited to nonunion mining companies, which are on average much smaller than unionized ones. Limiting to these companies makes it yet more likely that regulation had little effect on the firms in this sample, since safety regulation is considerably less enforced in small, nonunionized mines (Weil, 1987).

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[21]Several studies have documented a decrease in coal mine fatalities following this law but an increase in total accidents, perhaps due to better reporting (Neumann and Nelson, 1982; Weeks and Fox, 1983, Boden 1985). Given the nature of the data and variables used in these studies, it was not possible to ascertain whether these effects had begun by 1971. However, in Kentucky, the 41 coal mining fatalities in 1971 was hardly different from the 42 annual average fatalities in 1962 to 69 (1970 was considerably higher due to a single large and deadly mine explosion.) However, the number of fatalities fell to less than 30 in each of 1972, 1973 and 1974 (Kirkpatrick, 1971, 1974).

[22]Unions can affect accident rates in mines for various reasons, e.g. income effects of higher union compensation, differing turnover, differing rules governing job changing (Connerton, 1978), reflecting median rather than marginal workers (Freeman 1981), etc. In the UMW, the fact that retired miners continue to vote may also skew safety levels (Neumann and Nelson, 1982). The empirical literature suggests that unions increase injuries in coal mines but do not affect fatalities (National Research Council, 1982; Appleton and Baker, 1984; Boden, 1985; Connerton, 1978). In a union environment, the theoretical model developed in this paper may not apply since management of union firms may not have the high level of direct control over safety required by the model.

In order to measure monopsony power's impact on occupational safety, the "market" must first be defined. Ideally, there should be easy mobility among jobs within the defined labor market but little mobility from these to other jobs. In most cases, labor market definitions will have a geographic and an occupational dimension. In the case considered here, the occupational definition -- coal miners -- is straightforward. The relevant geographic market is more difficult to define, but should capture the fact that the further a mine is from other mines, the less mobile its workers are. Accordingly, I have defined the geographic market as all mines within a ten mile drive. The choice of ten miles, or any other distance, is arbitrary. Ten miles was chosen since it entails a reasonably long commuting time, given that travel is along mountain backroads.

The game-theoretic sequential entry approach suggested that the number of different employers will affect the safety provided by each firm, as each employer chose its wage/safety based on the choices of safety/wage of employers already in the market and the predicted wage/safety choices of future entrants. Accordingly, the empirical results focus on the effect of N10, a simple count of the number of alternative companies operating mines within a 10 mile drive. (Note that many companies own and operate several mines.) There is also an intuitive interpretation of this variable in terms of monopsony power: the more alternatives available, the less the monopsony power of any particular mine.

The industrial organization literature generally uses other variables to measure market power, particularly the concentration ratio (specifically, the proportion of the employment within a ten mile drive represented by the four largest firms, denoted CR4) and the Herfindahl index (i.e. the sum of squared market shares of employment within a ten mile drive). These variables capture whether the market is dominated by a few firms, a different concept than the number of different firms operating in the market. To see whether these variables independently affect the safety provided by the firm, I have included them in different specifications of the accident rate equation.

Finally, the Spence/Viscusi approach suggests that the major effect of monopsony on safety is by limiting the labor hired, moving down the labor supply curve. There is no way to unambiguously capture the labor restriction effect of monopsony. If mines are pure monopsonies, the firm's employment level will reflect the extent to which the firm has restricted labor. However, firm employment is very likely to be capturing factors other than monopsony. For instance, it may be capturing the direct link between different technologies, determined by the type and size of coal deposits, and accident rates. It may also capture the tendency of larger companies to have better reporting practices, due to either higher visibility or to better statistical capabilities.

In an oligopsonistic framework, total employment in the specific labor market (here, mine employment within the 10-mile distance[23]) seems to best capture the extent to which labor demand has been restricted. However, this variable will be affected by numerous factors besides market power, including population of potential workers and geographic differences in coal distribution.[24] A final

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[23]This includes the mine's own employment.

[24]Accident proneness further obscures the interpretation of the relationship between EMP10 and occupational safety. The dependent variable, the accident rates, combines two elements: the level of safety provided by the firm and the inherent accident-proneness (and carefulness) of the worker. Even if population levels were identical in two regions, a positive effect of EMP10 on accident rates need not mean that employment is negatively related to firm-supplied occupational safety. Instead, differences in average accident proneness could be responsible for this result. To see this, note that to the extent that workers differ by accident proneness only, at lower employment levels the average worker hired will tend to be less accident prone since less accident prone workers are less costly (ceteris paribus, it costs more to bring accident prone workers to any given level of utility, plus there are direct costs to the employers of accidents) and thus will be hired first. If, on the other hand, increasing EMP10 lowers accident

interpretation to this variable may be as a measure of the alternative opportunities available to a miner (in the same spirit as the variable for the number of mines within a ten mile drive). In this interpretation also, higher values of employment within a ten-mile drive (controlling for employment in the mine itself) signals less monopsony power.

Because of the ambiguity of interpretation of both own employment and employment within a ten mile drive, these variables will be included in specifications but will not be interpreted as isolating an effect of monopsony power.

The estimation also includes the general unemployment rate in the region, which may be negatively related to the alternatives (mining and non-mining) available to the worker.[25] Accordingly, higher unemployment rates strengthen the monopsony power of the employer. They may also be correlated with accident rates because they indicate rightward shifting supply of labor (and perhaps left shifting demand of labor) to the local mining industry, lowering total compensation and, since occupational safety is a normal good, lowering safety too.

III. Data, Estimation and Results

The Kentucky Department of Mines and Minerals publishes a mine-by-mine account of annual production, employment, accidents and fatalities (Kirkpatrick, 1971. In these data, accidents are not differentiated by whether they caused lost workdays.) From these data, the dependent variable, accidents per thousand workdays, was calculated. Several authors argue that fatalities, or at least,

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rates, this could not be due to differing average accident proneness.

[25] This view assumes that unemployment exists because labor compensation is slow to adjust to cyclical and sectoral changes.

permanent injury accidents are more reliable measures of accident rates since they are less likely to be underreported or to be affected by statutory changes. (See Weil, 1987, National Research Council, 1982.) However, since there are so few fatalities per year, results using fatality rate per mine are not very powerful and are likely to be very unreliable. Moreover, there seems little a priori reason to expect that use of the accident rate (rather than fatality) variable would bias the coefficient of monopsony power or of the number of nearby mines.[26]

The number of mines that are accessible to the same group of workers and the employment level in these mines was calculated by assuming that workers who worked at a particular mine could consider their range of highly substitutable alternatives to be all other coal mining companies within a 10-mile drive from the mine where the worker was presently employed. Each mine was located on a detailed road map, and this enabled calculation of the number of mines and level of employment in coal mines (other than the mine in question and others owned by the same company) within a 10 mile drive.

In addition to "mine employment", two other variables were included to control for technological determinants of accident rates, tons mined per worker-day and a dummy for underground mines.[27]

The measure of regional unemployment was the county unemployment rate.

The union status of a mine was difficult to ascertain. In 1971, the United Mine Workers was a powerful force in Kentucky, although Eastern Kentucky was

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[26]In contrast, many authors feel that the effect of unionism would be biased when using accident rate data as opposed to fatality data, since reporting is likely to be very different in union environments. See for instance Neumann and Nelson, 1982, Weil, 1987 .

[27]In either a hedonic competitive model or an oligopsonistic game theoretic one, technological factors can determine where each particular mine positions itself in wage/safety space.

always a non-union stronghold. Unfortunately, until recently the UMW did not publish or gather lists of the specific mines unionized. The separation of mines into union and nonunion is thus inexact, based on discussions with several UMW officials in the different mining districts of Kentucky. The final sample included 760 mines, many of them quite small.

Because many mines have no accidents whatsoever, there is a bunching of the dependent variable (accident rate) at zero. Therefore, a tobit model was used to correct this bias. The tobit model assumes that there is a latent variable p(a) measuring the underlying tendency to have accidents (that can be positive as well a negative), and is a function of the exogenous variables x:

$$p(a) = x\ b + e$$

where e is normally distributed.

If there are significant county effects that are correlated with the included variables, all parameters will be biased. A test of this fixed county effects model was performed by introducing county dummies. It was impossible to reject the hypothesis that there are no county effects ($\chi^2_{21} = 24.83$, $Prob[\chi^2_{21} > 32.67] = 0.05$) Therefore, we ignore this kind of fixed-effects misspecification bias.[28]

Results for estimates without county fixed effects are presented in Table 2. Several specifications are given which include different combinations of the three different measures of monopsony power.

The first three columns report the results when the three measures of monopsony power are entered individually. Since these three variables all attempt

[28]There can be serious problems introduced with this simple solution to fixed effects, i.e. using group dummies, is used in a tobit model or any nonlinear model (Chamberlain 1980). This is not a problem here because the number of mines in most counties is large.

to measure the same concept, monopsony power, entering them simultaneously might tend to obscure interpretation. When entered separately, the number of alternative mining companies within a ten-mile drive has a negative effect on accident rates, or a positive effect on occupational safety. More choices lead to more safety, so that monopsony's effect on limiting alternatives would decrease occupational safety. The intuition of some noneconomists, that fewer choices of employment lead to less occupational safety, is borne out by the data. The policy implications of this key result are discussed in the concluding section. (Since the theoretical discussion suggested that the entrance of the second firm might have qualitatively different effects than the entrance of later firms, I also tested models including dummies for one and two firms; they were always insignificantly different from zero and did not significantly change the coefficient on N10, either statistically or otherwise.)

On the other hand, the Herfindahl index, when entered alone, has no effect at all on occupational safety. Finally, it is difficult to tell whether the four-firm concentration ratio (CR4) affects safety. The coefficient is significant only at the 88% level. For those who take this as evidence that there may be an effect of this variable, the effect is consistent with the number of close-by mines variable, where more monopsony power raises accident rates or lowers safety.

When entered simultaneously, effects become much more ambiguous because of a high degree of multicollinearity, particularly between the Herfindahl index and the concentration ratio (r=.83). The significance of the number of mines within a 10 mile drive and CR4 fall, as expected. Surprisingly, when the Herfindahl index is entered simultaneously with the number of mines within a ten mile drive, it rises in significance, and the implication of the point estimate is that monopsony power increases rather than decreases occupational safety. The model where it most approaches significance (t=1.39) is specification (4) which includes all three monopsony measures. However, a likelihood ratio test rejects that this specification adds any explanatory power beyond model (1), which includes only the number of mines within a ten mine drive. (χ^2_2=2.12, P[χ^2_2>5.99]=.05). This, taken in combination with the clear insignificance of this coefficient when entered along, suggests that the Herfindahl index does not affect accident rates.

The number employed within a 10 mile drive, controlling for the number of mining companies within 10 miles, is positive and significant in many of the specifications, so that more area mining employment is negatively correlated with occupational safety. This is consistent with an interpretation that the employment restriction effect of monopsony increases, rather than decreases, safety, but as noted above, the coefficient is subject to other interpretations.[29]

The coefficient on the county unemployment rate is significant only when N10 is excluded from the specification, and in this case is negative, although we might have expected that high unemployment rates would decrease compensation, including occupational safety. The presence of this perverse result when N10 is excluded underlines the importance of controlling for N10. Of the remaining coefficients, only the employment (in workdays) in the mine is significant.[30] As

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[29]This coefficient could be capturing technological differences in areas that are heavily mined; it could be capturing the possibility that, in areas where mine employment is high, a higher proportion of the potential labor force is employed in mining so that people who are less qualified or skillful, and hence more accident-prone, are also hired; finally, it could be capturing monopsony-oligopsony effects in two ways: if EMP10 is higher when there is less oligopsony power to restrict area employment, the positive coefficient would imply that monopsony power increases: consistent with this, EMP10 could be another measure of alternative choices available to the worker, so that more choices decreases occupational safety.

[30]In other studies, size seems to have different effects mining accident rates and on mining fatalities. Appleton and Baker, 1984, studying mines in Eastern Kentucky and Western Virginia, find an insignificant effect of employment on

mentioned previously, this variable is likely to be dominated by technological factors.

IV. Implications for Regulation

The clearest result from the empirical work in this paper is that, given the level of firm and regional industry employment, the extra choices offered by competition lead to a higher average level of safety. For this labor market, at least, when more alternative choices in the same occupation are offered, average occupational safety levels increase. The game theoretic models developed in Section I led us to expect that there might be a strong effect of the number of available choices on occupational safety, although the direction of the effect was unsignable theoretically. The empirical finding here accords with the outcomes of the simulations of the "exogenous model" in Table I that assumed a particular functional form for utility.

Other measures of monopsony power, the concentration ratio and the Herfindahl index, seem not to affect accident rates. It appears that in this market, the sheer number of available alternatives is what affects average accident rates, rather than whether there is a size predominance of a few firms.

The key question facing policy-makers, however, is not whether the fewer choices in a more monopsonistic market provides less safety than on average is provided by competitive markets, but rather whether the regulation of occupational

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injury rates. The National Research Council, 1982, finds a positive effect of employment on disabling injury rates, while Neumann and Nelson, 1982, find an insignificant effect of mine size (based on tonnage) on accidents. However, both the NRC and Neumann and Nelson find a significant negative correlation between fatalities and mine size.

Note that if there is measurement error in workdays here, since the dependent variable is constructed using this variable, this would bias this coefficient downward, so the true coefficient would be even more positive.

safety levels would increase or decrease welfare. Mandating an increase in safety would not eliminate monopsony power but instead attempt to cure one symptom of monopsony power, lower safety levels. In <u>any</u> of the theoretical frameworks discussed, this strategy would make some workers better off, others worse off, while decreasing profits. In the Spence (1975) single-firm framework he shows that regulating a higher level of quality may decrease or increase total welfare (i.e. total surplus) even when the unregulated outcome sets a lower safety level than optimal. In the game theoretic models discussed here, imposing a minimum safety level would narrow the range that firms can position themselves. This could have the effect of limiting the number of firms that can operate profitably in the market, thereby lowering compensation.

Regulation via raising safety standards thus seems an uncertain policy, whichever theoretical framework is appropriate, when monopsony is the source of poor safety performance. Instead of addressing the symptom, government intervention in "monopsonized" markets should be aimed at methods that diminish the strength of monopsony power. This would mean different policies in different contexts. Training programs could give workers alternative employment alternatives, and may be the best policy in this particular labor market. In others, diligent enforcement of rules against wage-fixing across employers might be called for. Finally, immobility of labor force is often caused by government itself. When people lose (actual or potential) unemployment benefits or other forms of government support and subsidies when they move states or areas, this obviously encourages immobility which, in turn, gives employers monopsony power.

Reducing monopsony power will improve employees' overall welfare and compensation. This paper suggests that an additional, indirect effect could be an increase in the average levels of occupational safety.

Table 1: Accident Rates in Numerical Simulation Results

	K=.2 X=.5	K=.5 X=.4	K=.2 X=.2
1 firm model	1.88	2.40	0.75
2 firm model: first entrant	2.04	2.61	0.81
second entrant	4.04	5.17	1.61
average*	2.68	3.43	1.07
3 firm model: first entrant	1.64	2.14	0.67
second entrant	2.62	3.39	1.06
third entrant	4.44	5.72	1.79
average*	2.42	3.12	0.98
4 firm model: first entrant	1.5	1.9	0.60
second entrant	2.0	2.6	0.80
third entrant	3.2	4.0	1.25
fourth entrant	5.5	6.9	2.15
average*	2.31	2.95	0.92

*averages are employment-weighted
K = reservation utility
X/Accident rate = costs of providing safety
See text for complete explanation.

Table 2

Determinants of Kentucky Mining Accident Rates
Nonunionized Mines

Tobit Analysis
(standard errors in parentheses)

variable name	(1)	(2)	(3)	(4)	(5)	(6)
constant	-3.39*	-2.76*	-4.13*	-3.98*	-2.98*	-3.17*
	(0.99)	(1.05)	(1.33)	(1.48)	(1.95)	(1.36)
annual mine workdays/1000	0.131*	0.151*	0.141*	0.133*	0.133*	0.131*
	(0.028)	(0.029)	(0.029)	(0.028)	(0.028)	(0.028)
tons/workday	6.78	6.35	7.46	6.87	6.22	6.59
	(5.84)	(6.35)	(5.77)	(5.90)	(5.90)	(5.91)
underground	0.375	0.015	0.210	0.346	0.323	0.364
	(0.483)	(0.479)	(0.485)	(0.483)	(0.483)	(0.486)
unemployment rate	-15.86	-27.32*	-24.60*	-16.66	-15.15	-15.52
	(10.57)	(10.25)	(10.14)	(10.67)	(10.59)	(10.68)
EMP10/100	1.59*	0.578	0.744	1.39*	1.63*	0.163*
	(0.55)	(0.413)	(0.411)	(0.60)	(0.55)	(0.058)
monopsony measures:						
Herfindahl index		0.053		-3.33	-1.56	
		(1.318)		(2.39)	(1.47)	
CR4			1.65	2.11		-0.31
			(1.05)	(2.17)		(1.36)
N10/10	-0.314*			-0.272	-0.368*	-0.337*
	(0.120)			(0.162)	(0.131)	(0.157)
Log likelihood	-387.2	-390.8	-389.5	-386.1	-386.6	-387.2

N=760

Definitions:

EMP10: number of miners working in all mines within a 10 mile drive
N10: number of mines within a 10 mile drive
CR4: four-firm concentration ratio
* : significant at the .05 level

REFERENCES

Appleton, William and Joe Baker. "The Effect of Unionization on Safety in Bituminous Deep Mines." Journal of Labor Research 5:2 (Spring 1984), 139-147.

Biddle, Jeff and Gary Zarkin. "Worker Preferences and Market Compensation for Job Risk." mimeo, July 1987.

Boden, Leslie. "Government Regulation of Occupational Safety: Underground Coal Mine Accidents 1973-75." American Journal of Public Health 75:5 (May 1985), 497-501.

Chamberlain, Gary. "Analysis of Covariance with Qualitative Data." Review of Economic Studies, 47 (1980).

Connerton, M. "Accident Control through Regulation: The 1969 Coal Mine Health and Safety Act Experience." Unpublished dissertation (Boston, MA: Harvard University, 1978).

Dasgupta, Partha and Eric Maskin "The Existence of Equilibrium in Discontinuous Economic Games, I: Theory". Review of Economic Studies 53 (1986), 1-26.

Dickens, William. "Occupational Safety and Health Regulation and Economic Theory." in William Darity, Jr., ed. Labor Economics: Modern Views (Boston: Kluwer-Nijhoff, 1984.)

Freeman, Richard. "The Effect of Unionism on Fringe Benefits." Industrial and Labor Relations Review, 34 (1981), 489-509.

Gabszewicz, J. and J.F. Thisse. "Price Competition, Quality and Income Disparities." Journal of Economic Theory, 20 (1979), 340-359.

Hotelling, H. "Stability in Competition." Economic Journal 39 (1929), 41-57.

Kahn, Shulamit. "Occupational Safety and Worker Preferences: Is There a Marginal Worker?" Review of Economics and Statistics 49:2 (May, 1987).

Kirkpatrick, H.N., Commissioner. Annual Report of the Department of Mines and Minerals, Commonwealth of Kentucky, for the Year Ending December 1971,1974. (University of Kentucky, 1971, 1974).

Lane, W.J. "Product Differentiation in a Market with Endogenous Sequential Entry." Bell Journal of Economics 11 #2 (1980), p.237-260.

Levhari, David and Yoram Peles. "Market Structure, Quality and Durability." Bell Journal of Economics and Management Science, 4 (Spring 1973).

National Research Council Committee on Underground Coal Mine Safety. Toward Safer Underground Coal Mines. Washington D.C.: National Academy Press, 1982.

Neumann, George and Jon Nelson. "Safety Regulation and Firm Size: Effects of the Coal Mine Health and Safety Act of 1969." Journal of Law and Economics 25 (October 1982). 183-199.

Prescott, Edward and Michael Visscher. "Sequential Location Among Firms with Foresight." Bell Journal of Economics 8 #2 (Autumn 1977). pp.378-93.

Rosen, Sherwin. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." Journal of Political Economy 82:1 (January/February 1974).

Schmalensee, Richard. "Market Structure, Durability, and Quality: A Selective Survey." Economic Inquiry, 17 (April 1979).

Shaked, Avner and John Sutton. "Relaxing Price Competition Through Product Differentiation." Review of Economic Studies 49 (1) (January 1982), 3-13.

________________, "Product Differentiation and Industrial Structure." Journal of Industrial Economics 36:2 (December 1987), 131-46.

Smith, Robert S. The Occupational Safety and Health Act -- Its Goals and Achievements. (Washington: American Enterprise Institute, 1976.)

Spence, A. M. "Monopoly, Quality and Regulation." Bell Journal of Economics 6:2 (Autumn 1975), p.417-29.

Thaler, Richard and Sherwin Rosen. "The Value of Saving a Life: Evidence from the Labor Market." in N. Terleckyj, ed., Household Production and Consumption (New York: Columbia University Press, 1975.)

Viscusi, W. Kip. "Wealth Effects and Earnings Premiums for Job Hazards." Review of Economics and Statistics 60:3 (1978).

____________ "Union, Labor Market Structure, and the Welfare Implications of the Quality of Work." Journal of Labor Research 1:1 (Spring 1980.)

Weil, David. Government and Labor at the Workplace: The Role of Labor Unions in the Implementation of Federal Health and Safety Policy. Unpublished dissertation (Boston, MA: Harvard University, 1987).