# Workers' Risk Underestimation and Occupational Health and Safety Regulation

Drakopoulos, Stavros A. and Theodossiou, Ioannis

UNIVERSITY OF ATHENS, University of Aberdeen

March 2011

# WORKERS' RISK UNDERESTIMATION AND OCCUPATIONAL HEALTH AND SAFETY REGULATION

By

STAVROS A. DRAKOPOULOS
UNIVERSITY OF ATHENS

IOANNIS THEODOSSIOU
UNIVERSITY OF ABERDEEN

March 2011

Abstract

The standard treatment of occupational risk in the labour market is conducted in terms of the theory of compensating wage differentials, the basic characteristic of which is that workers can fully estimate actual occupational risks. However, research in cognitive psychology, and recent advances in economic psychology, suggest that individuals consistently underestimate risks associated with accidents. In this paper, we discuss the case when the workers systematically underestimate job risks. After presenting the standard treatment of occupational risks, and of health and safety at work regulation, we then proceed to incorporate the idea of job risk underestimation. The paper discusses the types and impact of regulation on health and safety effort in a simple framework in which workers' beliefs concerning accident risks also play a role. The paper shows that a particular type of regulatory intervention is necessary for the risk underestimating workers not to suffer a welfare loss.

## 1. Introduction.

Many studies on individual beliefs concerning risk have shown that people often underestimate and/or overestimate risks. For instance Kahnemann and Tversky (2000) suggest that in decision making people consistently underestimate outcomes that are merely probable in comparison with outcomes that can occur with certainty. They also argue that individuals are unlikely to perform the operation of subtracting the cost from the outcomes in deciding whether to buy a gamble. In addition, there is ample empirical evidence concerning similar behaviour towards risk in the context of occupational environment. Much specialist scholarship indicate that workers constantly underestimate their exposure to work risk for work accidents, since perceptions of risk are influenced by pre-existing, recent or readily available experiences (Thaler and Sunstein, 2008) or overestimation of personal immunity from harm (Weinstein, 1989).

This paper studies the repercussions of the above theoretical developments in the occupational safety and health framework (OSH) when the workers systematically underestimate job risks. In doing so the paper first briefly reviews the standard debate relating to the implementation of OSH. Although, it is generally accepted that there is a need for regulation in the case of job risk underestimation, there is no much work regarding the type of appropriate regulation. The paper provides a discussion of the types and impact of regulation on health and safety effort in a simple framework, in which workers beliefs concerning accident risks at workplace interact with the behaviour of Health and Safety regulator.

Thus, the following section briefly discusses the evidence of general systematic risk underestimation. Section 3 examines the implications of workers' risk

underestimation in the context of health and safety at work. Section 4 studies the behaviour of the health and safety regulator in the case when there is job risk underestimation by the workers and the interactions between the two. The final section summarises the main points and provides some conclusions.

## 2. Systematic risk underestimation

Research in cognitive psychology indicates that individuals consistently underestimate risks associated with accidents. Kahneman and Tversky, (1979), Kahneman et al., (1982); Slovic, (2000); Kahneman and Tversky, (2000) show that people tend to not evaluate appropriate information about the assumed risk. Tversky and Kahneman, (1974); Gilovich et al., (2002) suggest that individuals employ simplifying rules of thumb in decision making with respect to assuming risk. These rules of thumb lead to biases in the assessment of real risk and misplaced subsequent choices. Research in psychology also shows that the above rules of thumb are driven by an inbuilt resistance to unwelcome information which results in important cognitive limitations (Denscombe, 1993). In addition, people make systematic errors in their perception and predictions as current emotions influence assessments of the future, and thus they consistently misjudge their future emotions (Gilbert 2006, p.109). An implication of this is that the individual's assessment of future risk is shaped by current circumstances and emotions. Thus, individuals are found to overestimate the frequency of dramatic or sensational causes of death (homicide, aviation accidents) and underestimate the frequency of less well-publicised causes (such as stroke, asthma or a car accident) (Slovic et al 1982). For example, in an experiment carried out by Tversky (in Bernstein 1996) individuals were asked to

estimate the probability of dying from various causes. Their estimates exhibited a significant discrepancy compared to the actual statistical figures. They consistently underestimated some risks (e.g. natural causes) and overestimated others (e.g. unnatural causes).

Furnham (1988) and Thaler and Sunstein (2008) show that the individual's evaluation of risk is influenced by the immediacy of the event, the framing, the perception the individual's ability to control the risks and the anchoring. The individual's perception of risk is also affected by an 'optimism bias', as individuals are found to commonly overestimate their personal immunity from harm (Weinstein 1989), always assuming that hazards are more risky for other individuals than for themselves. Moreover, Rogers et al. (2000) and Lloyd (2001) offer evidence showing that individuals tend to underestimate the qualitative nature, and severity of outcomes, in terms of their current and future impact on their health or their functional status.

All in all, the evidence suggest that employees tend to underestimate the level, nature and severity of risk associated with the execution of job tasks. They consistently evaluate the likelihood of having an accident at work as being less likely than the actual risk they face, as predicted on the basis of statistical analysis and expert opinion.

## 3. Job Risk Underestimation and Health and Safety

The standard treatment of occupational risk in the labour market is conducted in terms of the theory of compensating wage differentials (CWD) (Rosen, 1986, Ehrenberg and Smith, 1997). This theoretical approach suggests that market forces ensure payment of wage premiums by firms to those employees who are employed in

risky job tasks, which premiums persuade workers to accept less attractive jobs that are associated with higher occupational risk. Hence, the theory predicts that wages rise with job risk, and that wages will be higher for more risky jobs other things being equal. The worker is thus able to choose from a menu of wage – job risk combinations that produces an indifference curve that relate wage levels and the risks of occupational injury.

Importantly, Purse (2004) criticizes this approach arguing that there are a number of crucial underlying assumptions of the theory that are problematic. In particular, the basic assumption for the theoretical validity of the CDW theory is that of labour mobility. This assumption might not hold in many cases, because of many market types, and due to institutional obstacles. In addition, workers might not be informed about workplace risks, and this implies that workers may seriously underestimate job risks. Finally, Purse (2004) provides a detailed discussion suggesting that the assumption that individuals are always rational decision makers, even under conditions of uncertainty and risk, is not consistent with empirical findings. Furthermore, since safety is a normal good, non-manual workers or those who enjoy a higher level of human capital can "afford" to select jobs with better working conditions (Biddle and Zarkin, 1988). Employers also offer superior market opportunities (both pecuniary and non-pecuniary) to high-skilled workers who have job-specific training (Viscusi, 1993). This implies that the wage-risk tradeoff is likely to be an increasing function of wealth, in which case the safer jobs are allocated to the highest paid individuals.

This has repercussions for the employee's estimation of level of the risk premium which they will require in order to compensate them for undertaking a hazardous job task. In view of the above, it appears that they will consistently accept

lower premiums, which in turn offer the opportunity and the incentive to the employers to provide a less than adequate level of health and safety. In terms of the standard treatment, Figure 1 shows the worker's indifference curves and the wage offer curve by the employer in the case where the worker systematically underestimates the probability of job injury risk.

(Figure 1 about here)

The worker believes that the job risk is at level $r_0$ with the corresponding compensating equilibrium wage at $w_0$. This combination lies on the workers' indifference curve $U_0$ and the employers wage offer curve is OC. However, if the real job risk is higher at the level $r_1$, then the worker unknowingly is taking "too much" risk for the given wage level. This means that although the worker believes that he/she operates at $U_0$, he/she is effectively at a lower indifference curve $U_1$. In order to remain at $U_0$ utility level, the worker should receive a higher wage rate equal to w'. Thus, the difference w'$w_0$ is the wage loss that the worker suffers due to his/ her job risk underestimation. Hence, in the context of the standard framework, government intervention, in the form of the provision of adequate information, the setting of standards or the imposition of financial penalties or prosecution, might be necessary to achieve equitable levels of OSH.

The standard approach to the behaviour of work safety regulator is that the regulator imposes a maximum level of job risk (Borjas, 2010). The way that the health and safety regulator imposes this maximum risk is not direct but through an array of safety measures and penalties (see Viscusi, 1986). Usually, the regulator targets firms where there is an increase in occupational accidents and imposes stricter health and safety rules (Bartel and Thomas, 1985; Ruser and Smith, 1991 describe a realistic approach of the functioning of health and safety regulator).

In terms of figure 1, if the maximum level of job risk imposed by the regulator $r_{max}$ is higher than the perceived job risk $r_0$ but lower than the actual level of job risk at $r_1$, and the wage rate remains the same, then the worker is at a lower indifference curve than $U_0$ but higher than $U_1$. In order for the worker to remain at the same indifference level $U_0$, he/she should be paid a higher wage than $w_0$. In this framework, it is clear that when the worker underestimates the probability of a work accident, then he/she suffers a loss either in the form of a lower wage, or of utility. Thus in the presence of systematic job risk underestimation, workers suffer a loss which can be alleviated only when the OSH regulator intervenes.

## 4. Workers' Risk Perception and the Regulators Safety Effort

The above section offered an overview of the repercussions of job risk underestimation by the worker and the assumed function of the health and safety regulator in imposing a maximum acceptable risk. As was mentioned, the way that the regulator does this is indirect. The standard approach is to assume that the regulator implicitly sets a maximum level of risk by safety inspections, citations and penalties. Inspections, backed up by the threat of penalties for non-compliance, may push employers to comply with standards, or even to improve their overall safety programs. Firms monitor the regulators' activity and respond in ways that decrease injury rates when perceived enforcement risk increases (Mendeloff, 1979; Viscusi, 1986). For instance, it has been found that in US, a 10% increase in enforcement activity reduced injuries by about 1% (Scholz and Gray, 1990). By using Canadian data, Lanoie (1992) reported that a 1% increase in occupational health and safety inspection rates

was associated with a 0.2–0.3% decrease in frequency of individual workplace injuries (see also Mendeloff, 2005 for a discussion of the general OSH impact on job injuries). However, there seems to be a lack of attention in the literature concerning the issue of the effect of health and safety regulations combined with workers' job risk underestimation, and of the interactions between the two.

One can investigate the above in a simple framework utilising research on risk perceptions. A discussion of the general case of the difference in beliefs concerning risk and regulation can be found in Viscusi, (1998); Salanie and Treich, (2009). In the specific context of safety at work, one can assume that there is a difference concerning the assessment of a job risk between workers and the work safety regulator, and that there is agreement between the two parties concerning all other preferences. Contrary to the standard approach, the health and safety regulator does not impose a maximum level of job risk but instead he/she adjusts the level of effort to work safety. Following the standard approach of the relevant literature on risk perceptions, the representative worker has quasi linear preferences given by:

$$U(h, e, Pw) = u(h) - (1-e)Pwh - c(e) \qquad (1)$$

Where

h: is the hours of work supplied by the worker with $h \geq 0$

u(h): is the workers' gross surplus (arising from hourly wages), assumed increasing and concave

e: is the level of regulator's effort to work safety, with $0 \leq e \leq 1$

c(e): is the per capita safety provision cost function assumed increasing and convex

Pw: is the probability of suffering a work accident as perceived by the worker with $0 \leq Pw \leq 1$

In view of relation (1), (1-e)Pwh is the potential worker loss which depends on the safety effort and the hours worked. Furthermore, the cost of safety effort is ultimately borne by the worker, through wage loss, as firms implement safety regulations. Initially assume that h (hours of work supplied) is exogenous. The safety regulator has different beliefs about job risk, Pr, and he/she is also aware of the workers beliefs Pw. This simple framework can illustrate how the difference between Pw and Pr affects the regulator's safety effort. The regulators' decision can be viewed as aiming at the reduction of work accidents.

At this stage assume two types of regulators: Type 1 maximizes the workers' welfare taking fully into account the workers' beliefs concerning job risks. This behaviour is analogous to respecting consumer sovereignty and is termed 'populist' in the literature (Hird, 1994). Type 2 regulator maximizes the workers' welfare taking into account his/her own beliefs or assessment based on objective statistical evidence concerning job risks. This behaviour is usually termed 'paternalist' and it is similar to that described in the literature on merit goods (Besley, 1988; Sandmo, 1983; Sunstein, and Thaler, 2003); Thaler and Sunstein, 2008). Type 1 regulator's problem is the following

$$\max_{e} U(h, e, Pw) = u(h) - (1-e)Pwh - c(e) \qquad (2)$$

The solution yields the following expression

$$Pwh = c'(e) \qquad (3)$$

Expression (3) implies that the marginal benefit, as perceived by this type of regulator, is equal to the marginal cost of safety effort. It is also clear that in the case that the worker underestimates job risk, that is Pw < Pr, the regulator under-invests in

safety provision and technology compared to the case when Pw = Pr. In the context of this study, this implies that the maximum risk imposed by type 1 regulator (the level of the safety effort determines the level of the maximum risk), is lower than the actual risk. In terms of Figure 1, the level of risk imposed, is lower than the objective $r_1$ and as a result, the worker suffers a loss under this regulatory regime.

Type 2 regulator is assumed to have an objective risk assessment of statistical probabilities of a work accident occurring and thus employs probability Pr. Then his/her problem is the following

$$\max_{e} U(h, e, Pr) = u(h) - (1-e)Prh - c(e) \qquad (3)$$

The solution yields the following expression

$$Prh = c'(e) \qquad (4)$$

Expression (4) implies that the marginal benefit as perceived by Type 2 regulator is equal to the marginal cost of safety effort. Clearly, in this case, the paternalist policy ignores the workers' conceptions of job risk and imposes health and safety effort which reflect the actual job risk probability $r_1$, in Figure 1. Under this approach, workers do not suffer a loss due to risk underestimation. The important implication here is that the type of regulatory bahaviour is central in ensuring that workers do not suffer welfare losses.

In most labour contracts, the hours of work are given. However, there are cases when the workers can choose the hours of work as in the case of part time work. This implies that workers may choose the hours worked in line with their perception concerning job risk and safety effort level, thus h(e, Pw). In this case, for a given

safety effort e, the worker chooses the hours spent at work h(e, Pw) to maximize U(h, e, Pw). That is:

$$\max_{h} U(h, e, Pw) = u(h(e, Pw)) - (1-e)Pwh - c(e) \qquad (5)$$

The solution yields the following expression

$$u'(h(e,Pw)) = (1-e)Pw \qquad (6)$$

Concavity of u(h) implies that relation (6) indicates that the optimal hours of work supplied are decreasing in the perceived probability of having a work accident and increasing in the level of safety effort. Thus, observed absenteeism may also be influenced by the above factors. Indeed, evidence suggest that the highest absence rates are observed in secondary sector occupations (Ose, 2005; Michie and Williams, 2003; Bokerman and Illmakunnas, 2008).

It is also interesting to investigate the response of the regulator when h is endogenous. Type 1 regulator will take into account only the workers beliefs concerning job risk, thus maximizes U(h(e, Pw), e, Pw) over the safety effort e. The difference in the behaviour of Type 2 regulator in this case, is that when h is endogenous, he/she has to take into account the workers' beliefs about risk. Thus, Type 2 regulator maximises U(h(e, Pw), e, Pr) taking into account his/her statistical assessment of job risk but also the workers' risk perception. If Type 2 regulator does not consider Pw, thus completely ignoring workers' beliefs, the regulator's utility function would be U(h(e, Pr), e, Pr). It is easy to see that the last policy is inefficient because it cannot correctly anticipate the workers' actual reaction and therefore it is a sub-optimal policy (for an analysis of these issues in a general framework of beliefs about risk, see Salanie and Treich, 2009).

Since the utility of hours of work supplied are linked with the level of consumption, a specific functional form of quadratic utility for demonstration purposes can be used. Following Romer, (2001) and Cantor, (1987), this can be:

$u(h) = -1/2(h^*-h)^2$ (7) and $c(e) = 1/2\,(e^2)$ (8)

With h* denoting the maximum hours of work. If it is assumed that the workers' hours are exogenous, then Type 1 regulator maximizes (2) with (7) and (8) in mind. The solution is

$e_{t1} = hPw$ (9)

By the same token, Type 2 regulator maximises (3) with (7) and (8) in mind. The solution is

$e_{t2} = hPr$ (10)

A comparison of (9) and (10) illustrates the previous general conclusion that work safety effort provided by Type 1 regulator will be lower than the one provided by Type 2 regulator if workers underestimate job risk and vice versa.

In Figure 2, we can see the work safety effort provided by Type 1 and Type 2 regulators. It is clear that in the case when $Pw < Pr$, Type 1 regulator provides lower safety effort than Type 2. Hence, the maximum job risk imposed by Type 1 regulator is always lower than the one imposed by Type 2 regulator. Thus, workers suffer a loss due to their job risk underestimation and the behaviour of Type 1 regulator.

(Figure 2 about here)

The behaviour of the worker and the regulator can be studied under an endogenous choice of work hours regime. Specifically, given the above, the

individual worker's optimal hours of work supplied are given by the solution of the problem:

$$\max_{h} U(h, e, Pw) = -1/2(h^*-h)^2 - (1-e)Pwh - 1/2\,(e^2) \qquad (11)$$

which gives

$$h = h^*-(1-e)Pw \qquad (12)$$

Relation (12) illustrates the general conclusion that the optimal work hours supplied will be increased if the safety effort increases, and will be reduced if the workers' concerns about job-related accidents increases.

Type 2 regulator maximizes (3) in the specific form given by (7) and (8). Thus:

$$\max_{e} U((h(e, Pw), e, Pr) = u(h) - (1-e)Prh - c(e)$$

s.t.

$u(h) = -1/2(h^*-h)^2$

$c(e) = 1/2\,(e^2)$

$h = h^*-(1-e)Pw$

The solution gives

$$e_{t2} = \frac{h^*Pr - 2PrPw + Pw^2}{1-2PrPw + Pw^2} \quad \epsilon[0,1] \qquad (13)$$

Expression (13) implies that the work safety effort provided by Type 2 regulator is decreasing and then increasing with the workers' belief towards job risk (Pw). The minimum of relation (13) is at identical job risks beliefs when Pw = Pr. In Figure 3

we can see that Type 2 regulator's safety effort is at a minimum only at identical job risk assessments between the regulator and the workers. After this point, the safety effort increases as the workers' beliefs concerning job risk are increasing (for illustrative purposes, h* has been normalized to unity).

(Figure 3 about here)

In contrast, Type 1 regulator maximizes:

$$\max_{e} U((h(e, Pw), e, Pw) = u(h) - (1-e)Pwh - c(e)$$

s.t.

$u(h) = -1/2(h^*-h)^2$

$c(e) = 1/2(e^2)$

$h = h^*-(1-e)Pw$

The solution gives:

$$e_{t1} = \frac{Pw\,(Pw- h^*)}{Pw^2 - 1} \in [0,1] \qquad (14)$$

As in the general case, Figure 4 shows that Type 1 regulator's safety effort is lower than Type 2 regulator's effort up to Pw = Pr and increases in accordance with the rise in workers' conception of job risk (for illustrative purposes, h* has been normalized to unity). Again, risk underestimating workers are suffering when Type 1 regulatory policy is followed. Furthermore, the important implication is that in all cases the difference in beliefs concerning job risks always calls for more regulatory intervention even when the regulator follows a Type 2 policy (for a discussion of the

general case, see Salanie and Treich, 2009). Furthermore, this is independent of the worker under-estimating the risk of a work accident.

(Figure 4 about here)

## 5. Conclusions

Research in psychology shows that individual perception about risk at work is influenced by pre-existing, recent or readily available experiences. Specifically, overestimation of personal immunity from harm has been shown to cause people to often underestimate and/or overestimate risks. This systematic bias in risk of accidents or illness at work underestimation makes the market solutions to OHS provision guided by the theoretical constructions of the Compensating Wage Differentials Theory ineffective in providing adequate OSH provision to those who are exposed to such risks. This paper studied the repercussions for the implementation of OSH and provided a discussion of the types and impact of regulation on health and safety effort. In particular, given that workers are very likely to systematically underestimate occupational risks, the paper examined the consequences of this combined with the bahaviour of safety regulators. The discussion indicated that when the safety regulator follows a policy entirely based on workers beliefs concerning job risks, will always provide less safety effort than a safety regulator who takes into account the objective risk probability too. This result holds for exogenous, but also for endogenous, hours of work. In terms of the standard OSH framework, this implies that the risk underestimating workers might suffer a loss even when there is regulatory intervention which follows their beliefs.

Thus, this study indicates that a particular type of regulation is necessary for an economy to attain efficient and equitable levels of OSH. The basis of this type of regulation is the actual probability of occupational risk. In this sense, the regulatory activity should take into account the objective probability of accident or illness at work for the particular occupation, and intervene by setting appropriate health and safety standards. Monitoring and enforcing these standards (by the imposition of financial penalties or prosecution to non-compliers) seems to be necessary given the observed tendency of workers' job risk underestimation .

REFERENCES


Bartel, A. and Thomas, L. (1985) "Direct and indirect effects of OSHA regulation: A new look at OSHA's impact," Journal of Law and Economics vol.8(1), pp.1-25.

Bernstein, P. (1996) Against the Gods: The Remarkable Story of Risk, New York: John Wiley & Sons.

Besley, T. (1988) A simple model for merit good arguments, Journal of Public Economics, vol. 35, 371–83.

Biddle, J. E and Zarkin, G. A. (1988) "Source worker preference and market compensation for job risk", Review of Economics and Statistics, 70(4), pp.660-667.

Bockerman, P. and Illmakunnas, P. (2008) "Interaction of working conditions, job satisfaction, and sickness absences: Evidence from a representative sample of employees, Social Science and Medicine, 67, pp.520–528.

Borjas, G. (2010) Labor Economics, 5th edition, McGraw-Hill.

Cantor, R. (1987) "Long term contracts, consumption smoothing and wage-profit dynamics", Journal of Macroeconomics, vol.9, (1), pp.59-70

Denscobe, M. (1993) "Personal health and the social psychology of risk taking", Health Education Research, 8(4), pp.505-517.

Ehrenberg, R. G. and Smith, R. (1997) Modern Labor Economics: Theory and Public Policy, New York: Addison-Wesley.

Furnham, A. (1988) Lay Theories, Oxford: Pergamon.

Gilbert, D. (2006) Stumbling on Happiness, London: Harper Press.

Gilovich, T., Griffin, D. and Kahneman, D. (2002) Heuristics and Biases: The Psychology of Intuitive Judgment, Cambridge: Cambridge University Press.

Hird, J. (1994) Superfund: The Political Economy of Environmental Risk, Baltimore: John Hopkins University Press.

Kahneman, D., and Tversky, A. (1979) "Prospect theory: An analysis of decisions under risk", Econometrica, 47, pp.313-327.

Kahneman, D., and Tversky, A. (Eds.) (2000) Choices, Values and Frames. New York: Cambridge University Press.

Kahneman, D., Slovic, P., and Tversky, A. (1982) Judgment under Uncertainty: Heuristics and Biases, New York: Cambridge University Press.

Lanoie P. (1992) "The impact of occupational safety and health regulation on the risk of workplace accidents: Quebec, 1983–87", Journal of Human Resources, 27(4), pp.643–660.

Lloyd, A.J. (2001) "The extent of patients' understanding of the risk of treatments", Quality and Safety in Health Care, 10, pp.i14-i18.

Mendeloff, J.M. (1979) Regulating Safety: An Economic and Political Analysis of Occupational Safety and Health Policy. Cambridge, Mass: MIT Press.

Mendeloff, J.M. (2005) "Inside the black box: How do OSHA inspections lead to reductions in workplace injuries", Law and Policy, 27 (2), pp.219-237

Michie, S. and Williams, S. (2003) "Reducing work-related psychological ill health and sickness absence: a systematic literature review", Occupational and Environment Medicine, 60, pp.3–9.

Ose, S.O. (2005) "Working conditions, compensation and absenteeism", Journal of Health Economics, 24, pp.161–188.

Purse, K. (2004) "Work-related fatality risks and neoclassical compensating wage differentials", Cambridge Journal of Economics, vol.28, pp.597-617.

Rogers AE, Addington-Hall JM, and Abery AJ (2000) "Knowledge and communication difficulties for patients with chronic heart failure: qualitative study". British Medical Journal, 321, pp. 605–7.

Romer, D., (2001) Advanced Macroeconomics, McGraw-Hill Higher Education, Boston.

Rosen, S., (1986) "The theory of equalizing differences", in Ashenfelter, O., Layard, R. (Eds.), The Handbook of Labor Economics, North Holland, Amsterdam.

Ruser A and Smith, R. (1991) "Re-estimating OSHA effects", Journal of Human Resources, vol.26, pp.212-236.

Salanie, F and Treich, N. (2009). Regulation in Happyville, The Economic Journal, vol.119, pp.665-679.

Sandmo, A. (1983) "Ex post welfare and the theory of merit goods", Economica, vol. 50, pp. 19–34.

Scholz, J. and Gray, W. (1990) "OSHA Enforcement and Workplace Injuries: A Behavioral Approach to Risk Assessment", Journal of Risk and Uncertainty, 3, pp.283-305.

Slovic P, Fischhoff B, and Lichtenstein S. (1982) "Facts versus fears: understanding perceived risk", in Kahneman D, Slovic P, Tversky A, (eds) Judgement under

Uncertainty: Heuristics and Biases. Cambridge: Cambridge University Press: 463–89.

Slovic P. (2000) The Perception of Risk, London: Earthscan Publications.

Sunstein, C.R. and R.H. Thaler, (2003) "Libertarian Paternalism", American Economic Review, Papers and Proceeedings, 93, pp. 175-79.

Thaler, R.H., C.R. Sunstein, (2008) Nudge – Improving Decisions about Health, Wealth and Happiness. Chicago: Yale University Press

Tversky, A., and Kahneman, D. (1974) "Judgment under uncertainty: Heuristics and biases", Science, 18, pp.1124-1131.

Viscusi, W. K. (1986) "The impact of occupational safety and health regulation, 1973-1983," Rand Journal of Economics 17 (2), pp.567-80.

Viscusi, W. K., (1993) "The value of risks to life and health", Journal of Economic Literature, 31(4), pp.1912-1946.

Viscusi, W.K. (1998) Rational Risk Policy, Oxford: Oxford University Press.

Weinstein, N.D. (1989) "Optimistic biases about personal risks", Science, 246, pp.1232–3.

.

**Figure 1**: The worker's indifference curves and the wage offer curve by the employer

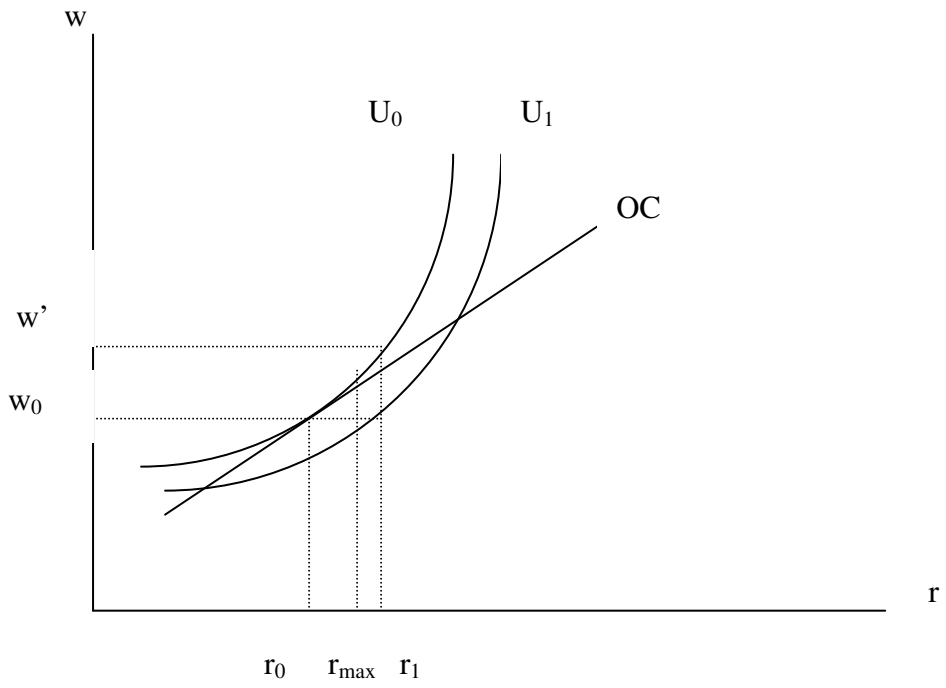


**Figure 2**: The work safety effort provided by Type 1 and Type 2 regulators when h is given.

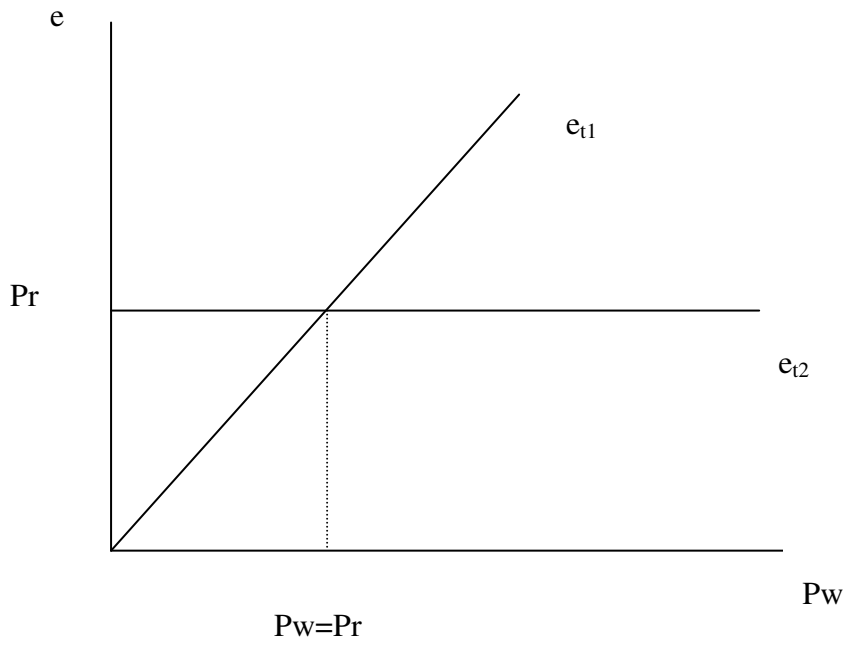

**Figure 3**: Type 2 regulator's safety effort when h is endogenous.

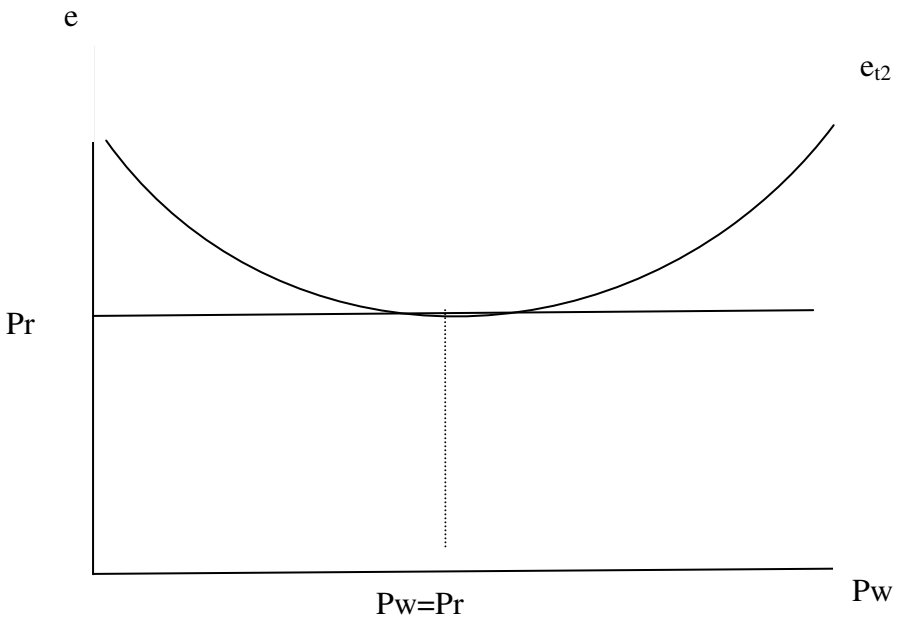


**Figure 4**: Type 1 regulator's safety effort when h is endogenous.