を検討するため，インターネットアンケートを実施した．

２．データ

２．１　インターネットアンケート調査

2010年2月18～22日，web上でインターネットアンケートを実施した．回答者数は2,958人（性別内訳＝男性1,446人，女性1,512人；雇用種別内訳＝正規雇用1,506人，非正規雇用1,452人），回答率は56.8%であった．アンケートでは性別，年齢，職業等の質問事項に加え，「認知ミス質問票（CFQ: Cognitive Failures Questionnaire）による調査を実施した．この質問票は，「家の中で，ある場所から別の場所に移動したとき，何のために移動したのかを忘れてしまっている」といった30項目の質問について，回答者に「非常によくある（=1)」，「よくある（=2)」，「ときどきある（=3)」，「ほとんどない（=4)」，「まったくない（=5)」から最も良くあてはまるものを選択してもらうものである．スコアの合計値（最小30点，最大150点）が低いほど事故傾性が高く，高いほど事故傾性が低いと判断する（Broadbent, *et al.*, 1982; Wallace, *et al.*, 2002)．さらにアンケートでは，最近5年間における労働災害および（通勤以外での）交通事故の被災回数についても質問した．

２．２　東洋経済CSRデータ総覧

企業レベルデータは東洋経済CSRデータ総覧から取得した．データは2008年の横断面データであり，サンプル数は387社（上場企業）である．取得したデータは労働災害度数率，全従業員に占める非正規雇用者の割合，全従業員に占める性別年齢別構成比率，従業員平均年齢，従業員平均勤続年数，月平均残業時間である．

３．結果

３．１　CFQスコア

労働災害について最近5年間で被災経験のある群（248人）の平均CFQスコアは87.9，経験のない群（2,710人）の平均CFQスコアは93.4であり，両者の差は統計的に有意であった（有意水準5%，以下同じ)．交通事故について最近5年間で経験のある群（375人）の平均CFQスコアは89.2，経験のない群（2,583人）の平均CFQスコアは93.2であり，両者の差は統計的に有意であった．これらのことから，CFQスコアは事故傾性の指標として利用可能であるとの先行研究の結果を確認した（図 6)．

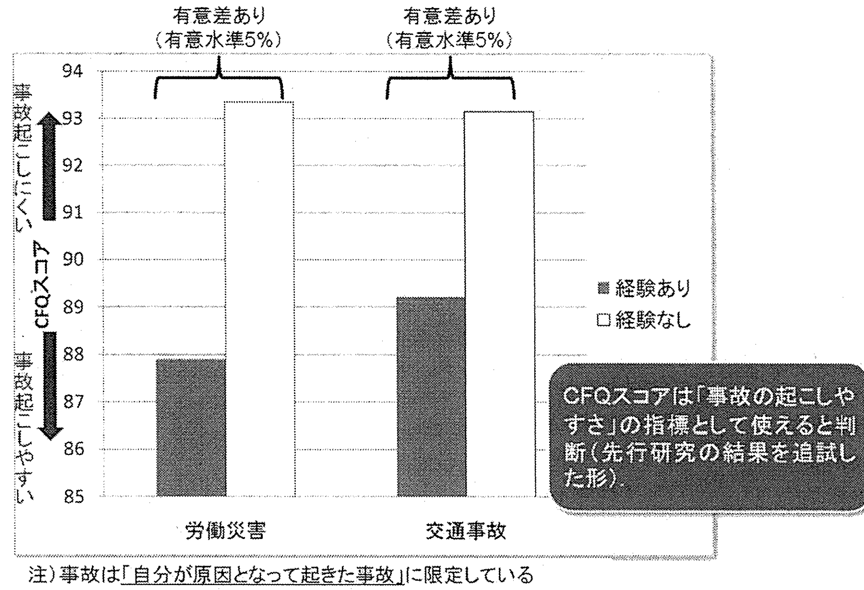

図 6 事故経験者および非経験者の CFQ スコアの比較

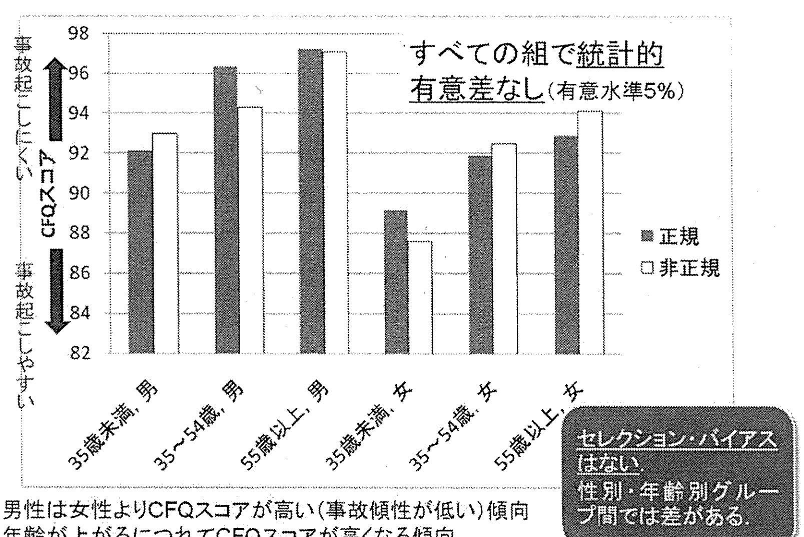

図 7 性別年齢別の CFQ スコアの比較

次に，正規雇用者と非正規雇用者との間で平均 CFQ スコアを比較した．性別および年齢別の影響を考慮するため，35 歳未満の男性（第 1 群，正規 248 人，非正規 240 人），35～54 歳の男性（第 2 群，正規 480 人，非正規 357 人），55 歳以上の男性（第 3 群，正規 76 人，非正規 45 人），35 歳未満の女性（第 4 群，正規 246 人，非正規 256 人），35～54 歳の女性（第 5 群，正規 412 人，非正規 479 人），55 歳以上の女性（第 6 群，正規 44 人，非正規 75 人）の各群に分けて分析を行った．第 1 群から第 6 群について正規および非正規雇用者の平均 CFQ スコアはそれぞれ (92.1，93.0)，(96.4，94.3)，(97.2，97.1)，(89.2，87.6)，

（91.9, 92.5），（92.9, 94.1）であった．すべての群について正規雇用者と非正規雇用者の平均 CFQ スコアに統計的有意差はなかった（図 7）．これはアンケート回答者となった正規雇用者と非正規雇用者については事故傾性に差がなかったことを意味する．この結果を根拠に，第 2 節に示した統計モデルを推定するにあたってセレクション・バイアスを考慮する必要はないと判断した．ただし，図 7 から明らかなように（1）男性は女性より CFQ スコアが高い（事故傾性が低い）傾向，（2）年齢が上がるにつれて CFQ スコアが高くなる（事故傾性が低い）傾向が観察される．そこで，統計モデルを推定する際には，企業 i の従業員の事故傾性を定量化する指標として，全従業員に占める性別年齢別構成比率を用いることとした．

３．２　企業データを用いた統計解析

図 8 に企業データを用いた統計解析の概要を示す．統計モデルの被説明変数は労働災害度数率，主たる説明変数は従業員に占める非正規雇用者割合である．図 8 に示したように，この変数の係数が正数で有意であれば，雇用契約効果の存在が示唆される．

労働災害度数率に影響を及ぼすと考えられる平均年齢，平均勤続年数，月平均残業時間，従業員に占める性別年齢別構成比率をコントロール変数として加えた．特に従業員に占める性別年齢別構成比率は従業員の事故傾性を定量化した指標と解釈できる．

サンプルである上場企業 387 社の中には労働災害度数率が 0 である企業も存在する．被説明変数は 0 以上の正数をとる（0 で切断された）データであるため線形モデルを適用することは適切でない（理論値としてマイナスの労働災害度数率が得られることを排除できない）．そこで統計モデルとして切断回帰モデルを採用し，最尤法による推定を行った．

$$
\begin{aligned}
\text{労災度数率}_i = &\ \alpha + \beta_1 {*} \text{非正規雇用者割合}_i \\
&+ \beta_2 {*} \text{平均年齢}_i + \beta_3 {*} \text{平均勤続年数}_i + \beta_4 {*} \text{月平均残業時間}_i \\
&+ \textstyle\sum_{(j=1,\ldots,m)} \gamma_j {*} \text{性別・年齢別構成比率}_{ij} \\
&+ \textstyle\sum_{(k=1,\ldots,n)} \delta_k {*} \text{産業ダミー}_{ik} \\
&+ \text{誤差項}_i
\end{aligned}
$$

雇用契約効果の有無を検出

従業員の「事故の起こしやすさ」を調整

- データ出典：東洋経済CSR企業総覧
- データ期間：2008年クロスセクション
- 企業数：上場企業387社
- 統計モデル：切断回帰（Tobit）モデル
- 推定方法：最尤法

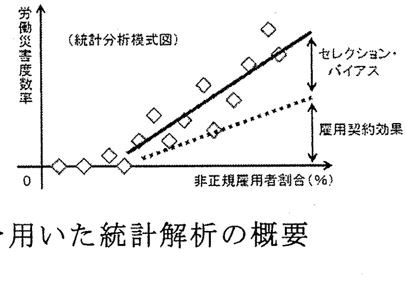

図 8　企業データを用いた統計解析の概要

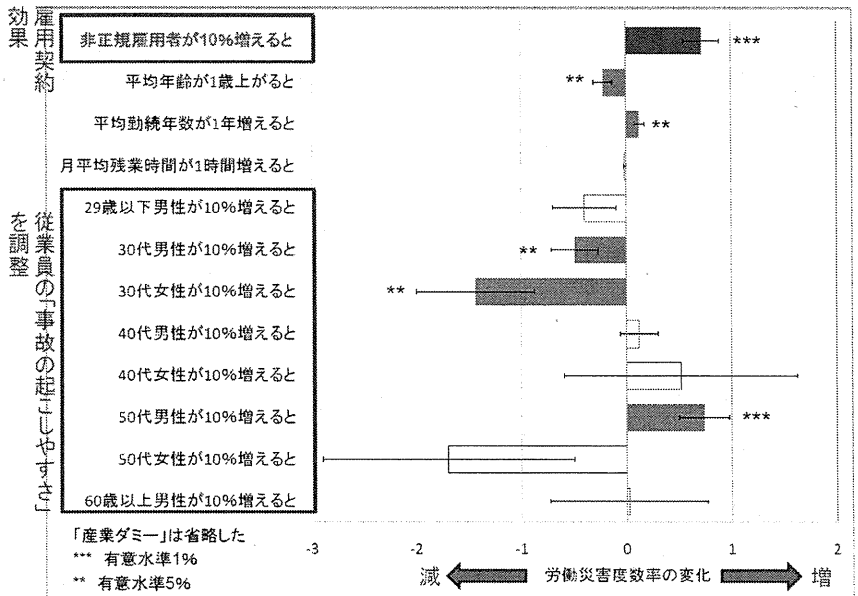

図 9　企業データを用いた統計解析の結果

図 4 に推定結果を示す．主たる説明変数である非正規雇用者割合の係数は（図 4 では「非正規雇用者が 10%増えると」と表示），従業員の事故傾性をコントロールした上で統計的に正に有意であった．これは雇用契約効果が存在することを示唆している．

コントロール変数については，平均年齢の係数が負に有意，平均勤続年数が正に有意であった．平均年齢が高い企業は労働災害度数率が低いとの結果は CFQ 調査結果で得られた「年齢が高いほど事故傾性が低い」との結果と整合的である一方で，平均年齢が高い企業は危険な作業を伴う事業を営んでいないことを示している可能性もあり，本研究で用いたデータからは由を確定することはできない．従業員の平均勤続年数が長い企業は労働災害度数率が高いという結果は，勤続年数が長くなり作業に慣れることによる「油断」の効果が，「危険回避に関する知識の蓄積」の効果を上回ることを示唆するものと考えられる．

４．まとめ

統計分析の結果は，諸変数の影響をコントロールした上で従業員に占める非正規雇用者割合が多い企業ほど労働災害度数率が高いことを示した．これは雇用契約効果の存在を示唆するものである．雇用契約効果が存在するならば，労働災害削減対策としては従来から指摘されている従業員への教育訓練の他に，労働契約のあり方を見直すといった方向性が考えられる．具体的な契約設計のあり方は今後の研究課題である．

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Occupational accident analysis with the notion of "incentive"

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Abstract: We propose a new approach to analyze the mechanism of occupational accidents, employing the economic concept of incentive. In the existing literature of occupational accidents, a human factor is regarded as one of the main causes of accidents. For the prevention of occupational accidents, therefore, human actions are considered to be the target of control. Accident reports in Japan usually place their focus on listing up of unsafe actions. But watchwords to stop unsafe actions which are often seen in occupational setting do not necessarily assure the change of worker's behaviors. From the viewpoint of economics, which has developed the analytical tools for actions, it is assumed that a man who took unsafe actions in an occupational accident must have had an incentive to do so. We argue that the most important thing in drawing plans to prevent occupational accidents is to provide proper incentives for managers and/or workers to avoid unsafe actions. We first illustrate the way of analyzing occupational accidents with the notion of incentives by introducing an example, and then discuss the possible applications to accident prevention plans.

Keywords: Occupational Accidents, Human Factors, Incentive, Economics

Introduction

To draw up effective occupational accident prevention measures, studying about and learning from past accidents are crucial. For this purpose, efforts have been made to collect information on past occupational accidents, analyze mechanisms of its occurrence, and develop systems that can easily be used by managers and workers on the job to browse through the analyzed results. In Japan, the Relational Information System for Chemical Accidents Database (RISCAD), the Petroleum Energy Center - Safety Assist For Engineer in Refinery (PEC-SAFER), and the Failure Knowledge Database are such systems.

There are roughly two possible approaches in analyzing the causes of and in planning preventive measures for occupational accidents. One method analyzes errors and accidents that occur in the nonbehavioral physical engineering systems, and the other approach analyzes human errors that occur in the behavioral dimensions of managers and workers.

For errors and accidents that occur in physical engineering systems, the method of probabilistic risk assessment (PRA) is well developed. However, researchers point out that the development in the understanding of the occurrence mechanisms of human error and assessment of probability of human error are rather behind when compared with the PRA method for physical engineering systems. For example, Bedford & Cooke (2001) pointed out that "Despite many years of research, there are still no very satisfactory models for human reliability" [1].

We believe that the current analytical methods used for the development of human error prevention measures are not entirely satisfactory for the following reasons. One reason is because the general trend in the current human error prevention measures does not go so far as to consider practically applicable measures to guide humans (for example, managers and workers) to behave in the way we desire (for example, safer behaviors). While emphasis on the importance of safety behaviors (to dissuade unsafe behaviors) itself may pose no harm, it offers neither analysis on practically applicable measures nor new ideas that can be used to guide others into behavior in a certain way. For example, in a situation where we wish to have workers wear safety belts, Takagi (2011) commented that "we must consider how workers can be encouraged to wear safety belts" [2]. The question here is the kind of measures that can be used to guide managers and workers to choose favorable behaviors.

To assess the occurrence mechanisms of human error and to design preventive measures against human error, we believe that the economic way of thinking, which is founded upon the concept of "incentives," and the game theory way of thinking that considers the notion of strategic interdependency among individuals are important. This is because we think that economics and game theory provide theoretical tools based on the concept of incentives to understand why people choose certain actions and thus offer a framework that can be applied to formulate solutions for this problem.

The research was conducted to claim the efficacy of the way of thinking used in the field of economics and game theory when analyzing occupational accidents and drawing up preventive measures. Although a preliminary version of this idea can be seen in the paper published by Hausken (2002), the idea remained highly abstract [3]. This is the first step of a series of research that aims to develop practical applications of this idea.

Methods

First, data on actual cases of occupational accidents involving human error were collected and organized. Various reports on occupational accidents, compiled in a database of accidents reported in Japan, were examined and occupational accidents that were caused by human error or organizational error were extracted. Information on the extracted accident cases such as the background of the accident, sequential development of the accident, details of human error, etc. were then organized. These were further categorized to reveal the occurrence patterns of the accidents.

Next, the basic idea behind the way in which the way of thinking used in the field of economics and game theory can be applied to the observed occurrence patterns of the accidents for formulating preventive measures, is organized and explained.

Case Studies of Occupational Accidents

Cases of occupational accidents recorded in the three databases listed below were chosen as the population of the study.

①RISCAD: National Institute of Advanced Industrial Science and Technology (AIST) and Japan Science and Technology Agency (JST)

② PEC-SAFER database: Petroleum Energy Center (managed by Japan Petroleum Energy Center since April 2011)

③ Failure Knowledge Database: Japan Science and Technology Agency (JST) (managed by Hatamura Institute for the Advancement of Technology since April 2011)

Cases of occupational accidents in each of the three databases were searched using keywords such as "human factor" and "human error" and a total of 212 such cases were found. Their breakdown was 38 cases in database ①, 154 cases in database ②, and 20 cases in database ③. Due to the characteristics of the databases, accidents included as the population of this search were confined to primarily chemical related accidents.

Of the total 212 cases of occupational accidents, 155 were judged from information written on the report as accidents that were due to strong influence of chance and were therefore excluded from further examination. This left 57 cases of accidents for categorization. Examples of the accidents are shown in Table 1.

Table 1 Examples of the accidents

ID	Title	Type of human error	Human error (in detail)
RISCAD 7276 (1984/6/4)	Fire erupted during reconstruction work of an oil tank at the oil refinery.	Lack of communication	① Insufficient exchange of information between the operator and safety personnel. ② When discussion was held on work that required the use of fire, it was unattended by the person in charge of the reconstruction work from the facility management side. ※ Routine work using fire, habituation, and indifference towards the management of hazardous materials.
PEC-SAFER 00340 (1996/9/24)	Eleven people were poisoned due to ammonia leakage.	The valve was opened by mistake (without confirmation).	・While loosening the flange in the line, a different operator opened the valve on the ammonia tank. (lack of instruction and communication)
PEC-SAFER 00148 (1987/6/11)	Fire due to smoking while cleaning sludge inside a crude oil tank.	Smoking while handling hazardous materials.	・Smoking while inside the tank of hazardous materials / routine and habituation (employee of a cooperative company)
PEC-SAFER 00308 (1985/12/21)	Large-scale fire due to explosion of petroleum products storage facility.	Liquid level inside the tank was not controlled. Wrong assignment.	・Two workers did not notice overflow from unloading tank. (lacked awareness that they were handling large quantities of hazardous materials, habituation)
RISCAD 07272 (1997/11/11)	High temperature pump of a vacuum distillation device exploded at the oil refinery.	Lack of communication (unreliable communication)	① Unclear transmission of basic procedures ・・・ clear on-site transmission ② Insufficient OJT for new employees (one year field experience) ※ Teach operation along with its reason

The cases were categorized according to the cause of occupational accidents. The cause of occupational accidents which was frequently raised by the incident reports are listed in Table 2. The five most frequently stated causes of accidents are examined below.

Table 2: Patterns of human error

Items	Cases
Lack of communication	21
Habituation	14
Inadequate staffing	6
Lack of training and/or ignorance	27
Misjudgment due to unwarranted assumptions	7
Breach of internal regulations	9
Lack of internal regulations	13
Inadequate safety measures at the corporate level	4
Violation of law	2

Lack of training and/or ignorance

There were many accidents that were thought to be caused by lack of knowledge such as operational procedures that the personnel in charge of the operation are reasonably expected to have knowledge of. This explanation goes hand in hand with the interpretation that the management had not trained their employees on indispensable knowledge. The thinking behind the solution that says that if lack of knowledge was the problem, teaching would be the answer, is simple and can easily be understood. However, the problem is not that simple. This is because simply having knowledge of something has no direct link with preventing accidents. Every driver knows that driving 100 km/h on an ordinary road is dangerous. However, despite this knowledge, people drive over 100 km/h for various reasons.

Lack of communication

Lack of communication typically appeared in the form of insufficient exchange of information. Unshared information among workers within the same department, among different departments within the same firm, and between companies (typically

with cooperative companies), became the cause of an accident. Three explanations as to why information may not be shared are raised as an example. ① Since exchange of information takes time, the workers omit to do so. Especially when the worker was to leave the field after the exchange of information, maybe the worker becomes (though nonconciously) somewhat careless. ② The worker mistakenly assumes that information that needs to be shared has already been shared. The worker makes the assumption (either consciously or nonconsiously) that whatever the worker knows must also be known by another. ③ The worker lacks understanding of the importance of information sharing. And for this reason, the worker had never even thought about checking whether information is shared or not.

Habituation

Even when the worker was engaging in activities that entail high risks when viewed objectively (such as short cut behavior and breach of rules), if the same action was repeated every day and days passed without an occurrence of an accident, the worker might begin to suppose that the high risk action cannot become the cause of an accident since it had not caused one all this time, and as a result, it might work to reinforce the high risk activity. In the case where it is handling of chemical substances, even when the substance is actually hazardous and must be handled with plenty of care, it is not difficult to imagine that as constant handling of the substance continues, one might begin to feel as if there were no danger in handling the substance.

Lack of internal regulations

This was the case in which the scope of work and work procedures were not clearly defined. This cause was often pointed out in accidents where lack of communication had also been attributed as one of the causes. The understanding behind this is that the lack of predefined rules regarding information sharing (the types of information to be shared, with whom, at what point, and how it should be shared) was the source of the problem. It is easy enough to point out the lack of regulations after the accident. However, it can be less than apparent as to what should be specifically included in the rule when the accident is yet to occur.

Breach of internal regulations

This reason was often pointed out along with misjudgment due to unwarranted assumptions. It can be inferred that assumptions such as it is all right, it is safe, there should be no problem with this operation, etc. all led to the conception that breach of regulation should pose no threat. There is also another commonly used reasoning which is that compliance entails cost. In this case, the cost does not always imply monetary costs. Generally speaking, compliance often demands physical, psychological, and time burden. Thus, it is thought that people breach regulations simply to avoid such burden.

Incorporation of incentives in the analysis

From here on, example analyses of occupational accidents using the economic way of thinking centering on the concept of incentives and the game theory way of thinking that deals with strategic interdependence are presented. The content of this section is indebted to Hausken (2002) [3].

Changing the definition of cost

When cost is mentioned, a large number of safety researchers seem to consider cost only in terms of monetary costs. However, costs cannot be limited to monetary costs. As pointed out in the previous section, compliance often demands physical, psychological, and time burden and these are also costs. On the other hand, greater disaster risk due to breach of rules is also a part of the overall cost. Actions of managers and workers are presumably intended to minimize this overall cost. In short, not only in monetary terms, but various costs are working as incentives to influence human behavior.

Considering the length of relationship among concerned parties

When it is apparent that the relationship is only temporary, the possibility of not being able to achieve cooperation (in this case, to take safety behaviors together) is high. It is not easy to establish cooperative relationships with people one may never have to work together again after the current (one time only) relationship. This is because cooperation generally entails burden. When the relationship is expected to last for a long time, cooperation might be achieved. This idea is formalized as the folk theorem. Even in analyzing occupational accidents, the relationships among concerned parties, especially whether the business relationship is expected to continue or not, must be taken into consideration.

Considering information held by the concerned parties

Normally, managers and workers do not completely know what type of person others are (for example, job competency, ability to assess disaster risks, discounting of the future, and physical fitness). In a situation where worker "A" does not know what type of person co-worker "B" is and thus impossible for A to predict B's next action and A's next action was to change depending on B's next action, to predict A's next move, one must know A's prediction of B's actions.

Incorporating the thinking of the principal-agent theory

Normally, workers work for corporate managers to receive pay in return. However, since it is difficult for corporate managers to directly observe the work performance of its workers, the workers have the incentives not to make the best effort. Under this circumstance, corporate managers need to create internal systems designed to generate incentives for the workers to strive for the best. The principal-agent theory formalized such problem. In the context of occupational accidents, workers must be given adequate incentives to select safety behaviors (or not to take unsafe behaviors).

Conclusion and Future Plans

In this research, we indicated the importance of incentives when studying the causes of human error in occupational accidents. Based on the results of this research, we are planning to construct a model that can be used to quantitatively simulate occurrences of human error.

Acknowledgement

This paper is a partial result of an ongoing research supported by the Health and Labour Sciences Research Grant as a Research on Occupational Safety and Health: Development of a Human Error Probability Quantification Method Based on Economic Game Theory (H22-Rodo-Young-007).

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インセンティブ（誘因）概念によるヒューマンファクターの理解：事故再発防止に向けて

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横浜国立大学大学院
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Understanding of Human Factors by the Incentive：For Prevention of Accidents

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キーワード：ヒューマンファクター，インセンティブ，規則違反，慣れ
Keywords：Human factors，Incentive，Rule violation，Experienced

1. はじめに

労働災害発生抑制の観点から化学災害をはじめとした既存の事故データベースの事故事例を精査してヒューマンファクターを抽出し，事故原因の背後に潜むインセンティブ（誘因）の側面から不安全行動の要因を探った．事故関係者によるどのような行動をターゲットとしてインセンティブ設計（アメとムチ）をすべきなのかという観点から見た事故再発防止の取組みの経過について報告する．

2. 新しい観点からの労働災害事例分析

各種の事故分析手法やツールでは，人的要因や組織要因を事故原因として抽出するという作業が既に行われている．例えば，一般に「なぜなぜ分析」や，産業技術総合研究所の「事故分析手法PFA（Progress Flow Analysis：事故進展フローを用いた事故分析）」などでは事故の根本的な原因を検討した結果，しばしば人的要因や組織要因の存在が浮き彫りに

なる．

しかしながら，たとえ人的要因や組織的要因の存在を認識するに至ったとしても，その改善策を実行しようとする際に解決すべき問題が色々と待ち構えている．

今回の新たな観点である"インセンティブ"とは「人々の意思決定や行動を変化させるような要因」のことである．「ある人がある行動をとった背景には，その行動をとるインセンティブがあった」と考える．作業者が被災リスクの高い行動をとったならば，その背景にはそうするインセンティブが働いていたと考える．当事者は自分がインセンティブに反応していることに自覚的である場合もあれば，無自覚である場合もある．事故を分析する際に，単に「…という行動に問題があった」と指摘するだけでなく，もう一歩踏み込んで「その行動をとったのは，作業者にどのようなインセンティブがあったからなのか」という視点を持たない限り，真の事故原因は見えてこないのではないかと考える．

また，既に発生した事故原因を考察する場合だけでなく，これから起こる（潜在的な）事故予防対策を講じるためにもインセンティブの考え方は必須である．対策を立てても，皆がそれを実行に移すかどうかは別問題である．適切なインセンティブ設計によって対策を確実に実行させる工夫が必要となる．インセンティブは必ずしも金銭や物品等に限らない．たとえば，昇進，名誉といったものもインセンティブになり得る．事故予防対策は，その工夫がない限り真の本質的な事故防止策にならない可能性があると考える．

2.1　インセンティブの例

交通事故事象での話に置き換えると，インセンティブの"アメ"部分として「ゴールド免許」（1994 年 5 月施行）の制度がある．この制度において，更新期間延長による実質的更新手数料の軽減，任意自動車保険料金の軽減（一部の業者）が行われた．しかしながら，これにより交通事故（死亡）の大幅な減少には繋がらなかった．

一方，インセンティブの"ムチ"部分としては，道路交通法の「改正道路交通法」（2002 年 6 月施行）での飲酒運転の罰則等の強化，さらに「自動車運転過失致死傷罪」「危険運転致死傷罪」「飲酒運転に関する厳罰化」（2007 年 9 月施行）その後の罰則等の強化での①飲酒運転者への罰則強化 ②周辺者への罰則の新設などがある．これにより 2007 年における飲酒運転による死亡事故は 10 年前の 1997 年と比較して約 3 分の 1 に減少した．

しかしながら，厳罰の中で新たな問題点が生じた．それは“危険運転致死傷罪”の適用を恐れて逃げる事例が出てきたことである．ここでは，インセンティブ（アメとムチ）の方策，重さ，対象範囲などのバランスに難しさがあることを指摘するに留めておく．

本研究の主軸は，ヒューマンエラーの原因分類で ①意図しない行動と，②意図的行動に分類した上で，「違反行動タイプ」にどのようなインセンティブが作用しているか？というところにターゲットを絞り込み解析を進める．（表1）

表1. ヒューマンエラーの原因分類 [1)]

No.	タイプ	詳細
①	意図しない行動	うっかり（忘却，看過，誤判断），考え不足（浅慮，無思慮），惰性（思い込み，習慣），自失（不判断，未知遭遇）など
②	**意図的行為**：違法性認識あり（バイオレーション，サボタージュ）	**規則(ルール)違反**：**逸脱，無視，省略（近道）** **不遵守，無関心，横着（手抜き），慣れ**

2.2 事故事例の収集

事故収集の第一段階として，化学，石油，石油化学関係でそれぞれのデータベース [2-4)] から，ヒューマンエラーなどの事故事例を検索し，合計 212 件が抽出された（重複を含んだ件数）．それらの事故報告を詳細に読み，そのうち純粋なうっかりミスと考えられるものや偶然要素が高いと考えられるものを除外した“57 事例”について①事故原因の概念モデルによる分類，②エラー内容による分類を行った．

第二段階では，全業種（機械，建設，航空・宇宙，金属，電気・電子・情報，自動車，食品，電力・ガス，鉄道，原子力，船舶・海洋，その他；化学，石油，石油化学を除く）の 948 件の事故事例について，ヒューマンエラーなどの事故事例を検索し，“103 件”が失敗知識データベースから抽出され同様の分類を行った．

2.3 事故事例の分析

事故事例における人的要因，組織要因の記述を系統立てて整理する方法として，以下に述べるアプローチをとった．『原子力・航空・鉄道・化学・宇宙開発分野の事故・トラブル

98事例から学ぶ巨大システム事故・トラブル教訓集』[5]は，分野横断的に事故原因の体系化を図ることを目的とし，Frank H. Hawkinsによる「SHELLモデル」をベースに，「装置・設備」「人間」および「組織」という3要素から巨大システムが構成され，その外側に「社会」が存在するというモデルを提示している．本研究では，上記の4要素にさらに「化学物質」を加えて作成された“事故原因の体系化モデル”[6]に基づいて事故の分類整理を行うことを試みた．このモデルでの分類作業では，より幅広い視点でその要因を読み取ることで事故内容を包括的に整理できる．

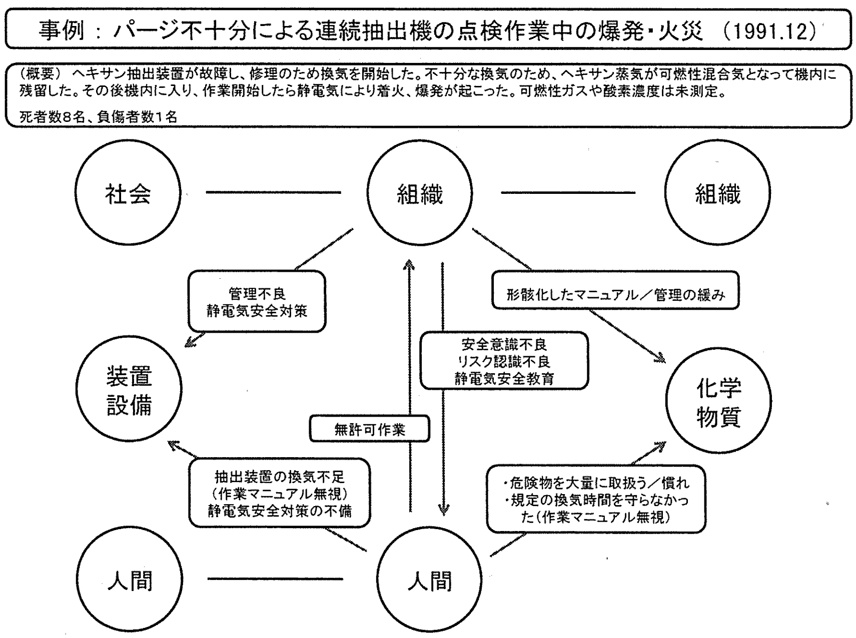

図１．事故事原因の体系化モデル分類例[4,6]

図1から明らかなように，ひとつの事故でも多数の原因が関係している場合がある．また，どの要因とどの要因が関連して発生しやすいかという観点でも整理できる．

このことは，事故対策として個別の原因をひとつひとつ除去するだけでは不十分であり，対策は「パッケージ」として提案する必要があることを示唆している．設備や化学物質のリスク評価をするだけでは不十分であり，リスク評価結果を周知して，そして作業者がそれを理解したことを確認してはじめて，事故予防対策としての実効性が期待できる．

インセンティブの観点からこの事故の原因に関する仮説を立てると，以下のようになる．

・常時，危険物を大量に取扱い作業していることから“慣れ”が生じ，注意するインセンティブが低下してしまったと考えられる．
・作業時間を短縮したい等の理由から，規定の換気時間を守るインセンティブが低下したと考えられる．
・許可を受ける手間を省きたい等の理由から機器内作業を無許可で行うインセンティブが上昇したと考えられる．

上記事例のような組織や作業者による問題行動を適切な行動に変えることを促すために，どのようなインセンティブ設計を行えばよいのか（＝どのような「アメとムチ」を与えればよいのか）について，今後，経済学的分析手法に基づいて検討する．

3. まとめ

人にインセンティブを与えて（＝「アメとムチ」を駆使して）変えることができるのは，人の「行動」である．したがって，事故報告書を読解し，その事故が進展していく中で各人・各組織がとった「行動」を明確に把握することが重要である．事故報告書や事故事例データベースでは，事故情報の現象面（誰が，どのような設備で，何をしたなど）はよく整理されている場合が多い．しかし，「事故関係者がなぜその行動をとったのか」という「インセンティブ」の部分は触れられてないことが多い．もちろん，事故報告書には，事故に直接関係している確証のある事柄しか記載できないということがあるだろう．しかし，なぜ各人がそのような行動をとるに至ったのかを捉えない限り深い事故原因の解明または事故抑止対策の立案もままならない．もちろん「インセンティブ」概念は人間行動を理解する唯一の方法ではないが，事故の分析に応用可能な分析手法や分析例等の知見が蓄積されていることを鑑みれば，有望なアプローチであり，事故原因の概念モデルに基づく分類と併せれば，事故を重層的に理解することができると考える．

今後，以下の点について，精査して行きたい．
①事故関係者の各人がどのようなインセンティブのもとに行動していたのか．
②事故関係者のどのような行動をターゲットにしてインセンティブ設計すべきなのか．
③事故関係者のリスク認識の甘さ＝“慣れ”がインセンティブにどのように作用するのか．

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＜対外発表（投稿中原稿）＞

Are Flexible Workers Truly More Accident-prone?

Abstract

Numerous studies have investigated the greater frequency of occupational accidents on the part of flexible employment workers (FWs), in comparison to permanent employees, and it is unclear whether the mere fact of being an FW contributes to this greater incidence. Although these studies conducted detailed statistical analyses, some important confounding factors respecting workers' occupational accident involvement risk were not included in the analyses, probably owing to database limitations. The aim of this study is to reconsider the factors influencing workers' occupational accident involvement risk using characteristics data respecting 2,882 Japanese workers and their firms, collected through an Internet survey, which contain newly introduced variables. In summary, our findings suggest that: (i) being an FW *per se* does not affect the accident involvement frequency; (ii) neither increased worker job experience nor safety training necessarily decrease workers' chances of accident involvement; (iii) workers' proneness to accidents seems to have no bearing on accident involvement risk, except in the case of construction workers; (iv) a worker witnessing someone being punished for rule violation or injured in occupational accidents has no influence on accident involvement reduction; (v) occupational accidents tend to happen in workplaces where the company's rules are violated; (vi) safety patrols by managers, and the introduction of an occupational health and safety management system, would be effective in occupational accident reduction. These findings may suggest that measures to develop organizational effectiveness respecting safety would be more effective than those to develop personal ability, in occupational accident reduction.

Keywords: Occupational accidents; Flexible workers (FWs); Permanent workers (PWs); Accident proneness; Cognitive failures questionnaire (CFQ).

1 Introduction

The number of workers hired as flexible employment workers (e.g., dispatched workers, contract workers, and part-time workers) has been growing in the labor market of Japan. The proportion of flexible employment workers (hereafter FWs) rose from 10.3% in 1994 to 13.7% in 2009. The implementation of the revised Worker Dispatching Act[1] of 2004 is considered the principal cause of this labor market change. The main provisions of the act were: (i) the extension of the permitted contract period for dispatched workers, and (ii) deregulation of dispatched workers in the manufacturing sector.

As the proportion of FWs increases, occupational accidents involving them are drawing attention as a social issue in Japan. On the basis of the data published by Japanese Ministry of Health, Labor and Welfare (MHLW, 2010), the injury rate[2] of FWs rose from 0.20% (2,437/1,240,000) in 2005 to 0.28% (5,631/1,980,000) in 2008, while that of all workers fell from 0.25% (133,050/53,930,000) to 0.23% (129,026/55,240,000)[3]. FWs appear to suffer greater insecurity in their job in comparison to permanent workers (hereafter PWs), in terms of higher accident risk, in addition to lower wages.

The Japanese government has been trying to decrease the number of occupational accidents involving FWs. For example, on March 31, 2009, the MHLW issued an Official Notice stating that it was important for companies that are supplied with dispatched workers to take appropriate safety measures to protect these workers from occupational accidents or adverse health effects (MHLW, 2009). In order to design effective accident reduction measures, it is necessary to explore the causes of occupational accidents in light of the characteristic differences between FWs and PWs.

In the academic literature, numerous empirical studies have examined the injury rates of FWs and PWs using the occupational accident data of various countries. Most of the studies agree that the injury rate of FWs is higher than that of PWs[4] (Jacobsson and Schelp, 1988; Aiken et al., 1997; Kirschenbaum et al., 2000; Amuedo-Dorantes, 2002; Guadalupe, 2003; Saha et al., 2004; Saha et al., 2005; Benavides et al., 2006; Hernanz & Toharia, 2006; Fabiano et al., 2008).

The most basic analysis consists of a simple comparison of the respective injury rates for FWs and PWs (as in Jacobsson and Schelp, 1988; Aiken et al., 1997; Salminen et al., 2003; Saha et al.,

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1 Act for Securing the Proper Operation of Worker Dispatching Undertakings and Improved Working Conditions for Dispatched Workers.

2 The injury rate is defined as the number of injured workers whose lost work time was more than three days (per year) divided by the number of workers (per year).

3 The statistics on the total number of Japanese workers are obtained from the web site of the Ministry of Internal Affairs and Communication (http://www.stat.go.jp/data/nihon/16.htm).

4 Salminen et al. (2003) and Saloniemi & Salminen (2010) concluded that there was no difference between the accident rates of FWs and PWs, using Swedish data.

2004; Saha et al., 2005; Fabiano et al., 2008). The principal limitation of such analysis lies in its failure to take into account the existence of potential confounding factors. In the last decade, some studies have focused on various factors behind occupational accidents (Kirschenbaum et al., 2000; Amuedo-Dorantes, 2002; Guadalupe, 2003; Benavides et al., 2006; Hernanz & Toharia, 2006; Saloniemi & Salminen, 2010). In their statistical analysis, some individual and workplace characteristics were added as independent variables to explain the variation in the injury rate of workers. The results, however, were ambiguous. Some studies concluded that being an FW did not affect a worker's likelihood of being involved in an occupational accident, when the influence of other variables, such as their job experience and the industries they belonged to, was controlled (Amuedo-Dorantes, 2002; Benavides et al., 2006; Hernanz & Toharia, 2006; Saloniemi & Salminen, 2010). On the other hand, there are studies suggesting that being an FW did have an impact on accident involvement risk (Kirschenbaum et al., 2000; Guadalupe, 2003). All these abovementioned studies conducted detailed statistical analyses, and most employed accident involvement frequency as the dependent variable. However, there are three possible problems with such analyses.

Selection bias: Suppose that accident-prone individuals tend to be hired as FWs. In this case, though statistical analysis may suggest that FWs tend to be involved in occupational accidents, this may simply reflect the fact that accident-prone individuals tend to be involved in occupational accidents. This would reveal what is called "selection bias." In the extant literature, only Guadalupe (2003) investigated such selection bias, and detected a "pure contractual effect;" that is, a direct impact of being an FW *per se* on occupational accident frequency. In order to rule out selection bias, a variable representing workers' accident proneness must be incorporated into the statistical analysis. Guadalupe (2003) used information on "the accident on the way to work" as an index representing worker's accident proneness, which was assumed to be independent of the work contract held. In this study, we solved the problem of selection bias by employing a more direct index to quantify workers' accident proneness as one of the explanatory variables in our statistical analysis; namely, the score on the Cognitive Failures Questionnaire. The Cognitive Failures Questionnaire is explained in detail in Section 2.

Work type: Information on the type of work done by sample workers was not fully taken into account in the extant studies. This may be due to the limitation of the databases used in these studies. However, accident statistics show that some types of work clearly tend to increase the probability of occupational accidents. In Japan, 589 workers died from a fall or a traffic accident, for example, comprising 50% of the total of 1,195 worker fatalities in 2010 (MHLW, 2011). This shows that occupational accidents tend to happen more in workplaces involving elevated work or traffic vehicle operation. Such contingent factors must be included in the statistical analysis.

Firm characteristics: Firm characteristics such as industrial category, normative consciousness of company rules, busyness, and implemented safety measures, would naturally have an impact on the occurrence of occupational accidents. Rule violation, for example, is noted as one of the unsafe actions that tend to lead to accidents (Reason, 1997). Firms that are very busy in their main business activity, as a result of a shortage of staff for example, may not be able to make sufficient efforts to reduce the possibility of accidents. In addition, reduction measures taken by firms, such as safety patrols by managers, would give workers an incentive to work more safely. Many extant studies do not take into account the impact of such factors on workers' accident involvement risk, probably owing to limitations on the databases employed.

In this study, we examine factors affecting variations in the number of occupational accidents, using the accident data of Japan. Taking into account the limitations of the extant studies mentioned above, we constructed a conceptual model representing occupational accident involvement risk of FWs, as shown in Figure 1. Factors influencing occupational accident involvement risk are assumed to be: (i) worker status (FW or PW); (ii) individual characteristics, including worker accident proneness; (iii) work type; and (iv) firm characteristics. We will pay attention to possible correlations between FW status and individual characteristics. The aim of this study is to reconsider the factors influencing occupational accident occurrences using newly introduced variables representing workers' accident proneness, work type, and firm characteristics, in addition to the variables that have been used in the extant studies.