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The Relationship between National Income and Occupational Injury

Rishma Vedd^{1*} and Nataliya Yassinski^{1*}

¹California State University, Northridge 18111 Nordhoff, Northridge, CA 91330-8372, USA.

Authors' contributions

This work was a collaboration by both authors. Author RV inspired this study. Author NY wrote the first draft of the manuscript. Together they teamed to accomplish all phases of this work. Both authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

In this paper, we analyze the relationship between national GDP and safety standards by determining if the rate of fatal occupational injury is high or low. We examine countries in two broad categories: The developed markets and the emerging markets. This study is limited for the seven year range of 2001 through 2007. Among the selected countries in the developed economies are the USA, Norway, Germany, and United Kingdom. Among the selected countries in the emerging market countries are Russia, India, Mexico, and Thailand. We determine that countries in the emerging markets have higher rate of fatal occupational injury compared to the countries with developed economies. This analysis also demonstrates that national income and safety standards relate by determining the level of rate of fatal occupational injury low or high.

Keywords: National income; Gross Domestic Product (GDP); occupational injury; safety standards.

1. INTRODUCTION

Is there a significant correlation between the wealth of a nation and its rate of fatal occupational injury? The quest to address that question is the focus of this study. In order to examine this problem it is deemed that the study must be limited to a manageable number of

*Corresponding author: E-mail: rishma.vedd@csun.edu, nataliya.yassinski.398@my.csun.edu;

selected nations that represent either developed or emerging economies. This study has narrowed the number of developed and emerging economies to four nations each. The main reason for this small sample size is that these eight nations have complete and pertinent data which has allowed for proper analysis and comparisons to be made. We are using a linear regression model to determine the relationship between the rate of fatal occupational injury, which is a dependent variable and the independent variable of GDP and the number of cases of fatal occupational injury. This study is not an exhaustive attempt to compare every major developed and developing economy. It is rather an analysis of four representative nations for each category to determine if a correlation does exist. With this limitation, the chosen emerging nations are Russia, India, Mexico and Thailand and the developed ones are the USA, Norway, Germany, and United Kingdom.

In order to show the relationship between these two sets of economies, a few assumptions have been made. The first assumption is that the developed economies have more robust regulatory statutes that better prevent occupational injury and that these laws are more rigorously enforced. The second assumption is that regulations in emerging economies are either less demanding and/or less assiduously enforced. Despite these assumptions, occupational accidents happen in all nations, even in highly developed economies. The Fukushima nuclear power plant accident in 2011, in Japan has killed an estimated 1,600 people from post evacuation conditions [1]. The evidence for this study is derived from statistics on these eight selected nations GDP, their number of workers, cases of fatal occupational injury, and their rates of fatal occupational injury. The connection between national income and occupation injury which may be empirically assumed is strongly verified by the data presented.

2. LITERATURE REVIEW

The key purpose of this study is to understand the core reasons of man-made accidents. Various researchers have studied similar questions to the one posed here. Khazai, Merz, Schulz and Borst have used a framework to describe a regions exposure to indirect disaster losses. This proposed framework enables the combination of sub-systems including industrial and social ones and identifies a regions vulnerability to losses. It further exposes the characteristic fragilities of the region and the coping capacities of the people within affected areas to deal with such damages. An advantage of this indicator-based approach is that it can be widened to include the vulnerability of other sub-systems such as Agricultural or Ecological. One of the key advantages of this technique is that it can identify the most vulnerable regions and even rank different regions as to their susceptibility. This in turn can lead to better planning and implement the most cost effective mitigation measures. The model is implemented through multi-criteria decision analysis software [2].

A study by Park (2011) has recognized a set of statistically significant relationships which quantifies the variables that determine the safety performance of a society. The findings largely confirm the inverted *u*-curve or Safety Kuznet curve. This hypothesis identifies the relationship between the safety performance in a society and its level of national income. These findings have some potential implications. The first is for the policy makers in nations that show a higher potential for man-made disasters. Included among these are the rapidly growing economies and newly industrialized countries such as China and India. The repeated mining accidents in China, for example, are likely the result of failure to comprehend the root cause of the disasters. The other major implication is for multinational insurance companies. They need to exhibit extra caution for those countries that are at

higher risk, and they can develop a better strategy which may be more culturally sensitive but may have a justifiably higher premium due to greater risk [3].

What may be the worst industrial disaster ever, may have resulted, according to recently released documents, from the attempt to reduce operating costs which led Union Carbide India Limited (UCIL) to cost cutting design flaws according to MacKenzie. The disaster which occurred at the pesticide plant in Bhopal, India on December 2–3, 1984 resulted in about 8,000 people killed and another 150,000 injured [4].

The central thesis of an investigation by Saaroni is that while the risk of disaster may be mitigated, not all disasters can be prevented. The very concept of risk itself is based on human perception and may not account for the infinite and unknown number of possible variables. It is not possible to find all risk factors that may result in industrial disasters. In those instances where crucial risks are identified, they still may not be manageable in an industrial setting which is usually a complex system. A further complication is that industrial complexes are created and run by humans. This alone puts doubt into industrial disaster prevention. Other factors such as environmental factors and conflict may also avert industrial disaster prevention [5].

Passariello reported in the Wall Street Journal that well-known American and Western retailers became part of factory disaster legacy of Bangladesh in 2012 and 2013. Tazreen Fashion Limited violated fire safety rules that resulted in tragedy affecting a great number of employees and their family. Tazreen Fashion Limited was making clothes for Walmart and Sears. Liberty Fashion Wears Ltd had structural failures at their facility, and the Rana Plaza Factory also had a structural fault that led to a collapsed building. With these aforementioned industrial disasters, many famous retailers associate, such as Hennes and Mauritz AB, Zara parent Inditex SA, British retailer Primark, part of Associated British Foods PLC, Tesco PLC, Carrefour SA, Debenhams PLC, PVH Corp., Calvin Klein, N Brown Group PLC, Wal-Mart Stores Inc., and Gap Inc. all demanded that the manufacturers enforce improved safety practices [6].

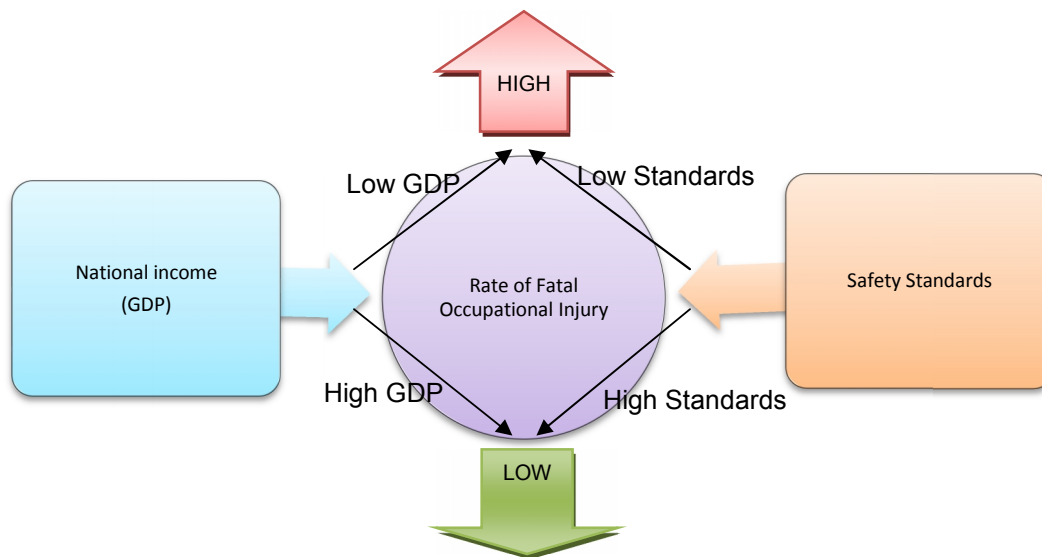
This literature examines major industrial accidents since 1917. The information from these has been used to create a database called MInA (Major Industrial Accidents) which exists at the Aristotle University of Thessaloniki, Greece. The authors of this work Mihailidou, Antoniadis, and Assael, have made some interesting observations. They revealed that developed nations had a far greater number of industrial accidents compared with developing ones. The U.S.A. is only one of the 52 nations in the study and yet it accounts for 193 out of the total of 319 documented accidents (39%). The study acknowledges that developed nations have far greater industrialization and thus a greater potential for industrial accidents, but the much lower numbers in developing economies for such accidents may also be due to “the political, economic or social conditions” which discourage proper reporting. Although the total number of accidents in developed nation is much greater, the mortality rate in developing nations is much greater. This rate for developing countries is about 254 deaths per accident compared to 14 per accident in developed nations [7].

3. METHODOLOGY

Our hypothesis is that the relationship between safety performance in a society and level of national income determine the occurrence of fatal occupational injuries (See Graph 1).

- H1: If the country has low criteria for safety standards then the country, the evidence shows, has more cases of fatal occupational injuries.
- H2: On the other hand, countries with higher safety standards generally have fewer cases of occupational injuries.

We compare four countries from the emerging markets and four countries from the developed economies. The four selected countries from the emerging markets are Russia, India, Mexico, and Thailand. The ones from the developed economies are USA, Norway, Germany, and United Kingdom. Our data focus on the country's Gross Domestic Product (GDP), its number of workers, the number of cases of fatal occupational injury, and the rate of fatal occupational injury.

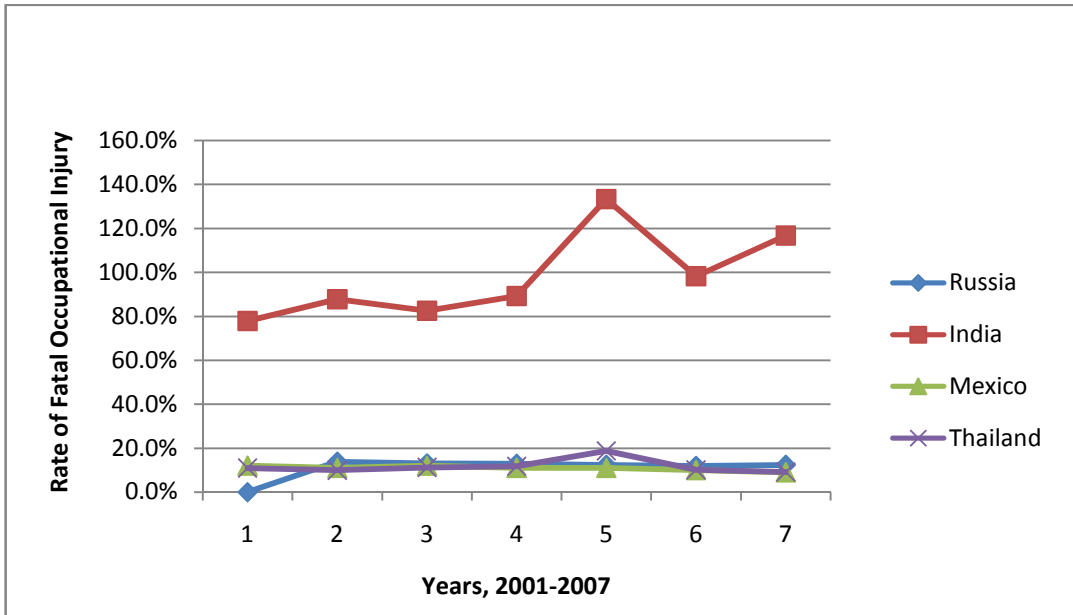


Graph 1. Factors influence on rate of fatal occupational injury

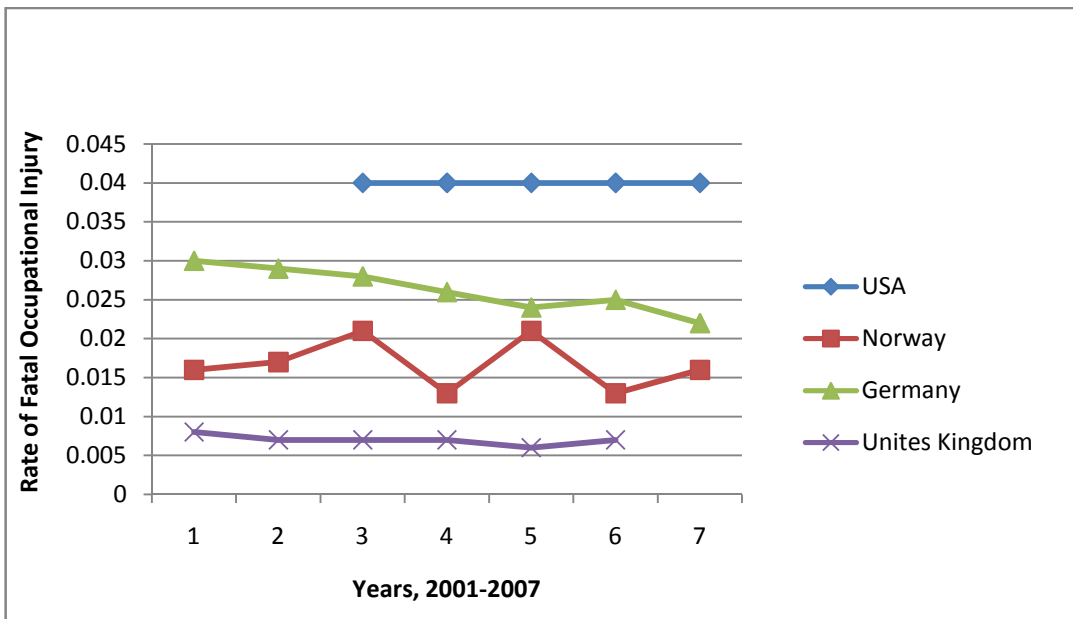
The trend of emerging and developed markets from 2001 through 2007 demonstrates that GDP is much higher in the developed economies than in emerging markets. Countries with the developed economies have GDP higher than \$2 trillion. On the other hand, countries from the emerging market have GDP lower than \$2 trillion. All statistics about GDP are derived from the World Bank database [8].

The rate of Fatal Occupational Injury in emerging market are higher, ranging from 10% to 117% compared to developed economies of only 0.6% - 4% (referring to Graphs 2 and 3). Cases and rates of fatal occupational injury data were collected from the International Labor Organization (ILO) database [9].

The rates for Russia, Mexico and Thailand are similar. The trend for India is significantly higher, compared to Russia, Mexico and Thailand.



Graph 2. Rate of fatal occupational injury on emerging market



Graph 3. Rate of fatal occupational injury on developed market

The rates for the four developed economies range from less than 1% to about 4%.

To assess the relationship between a dependent (rate of fatal occupational injuries in this study) and independent variables (the GDP and the number of cases of fatal occupational injuries), this study incorporates a descriptive-correlation. This relationship between variables

requires implementing a linear regression. The results are evaluated based on the Fisher F test, by utilizing SPSS software. The significance of the independent variables are assessed when the Fisher F statistic is less than 5% (Sig F <5%).

The following linear regression model (1) is used to test the hypotheses:

$$\text{Rate FOI}_n = \beta_0 + \beta_1 * \text{GDP}_n + \beta_2 * \text{Cases FOI}_n(x)$$

- Rate FOI_n - the rate of fatal occupational injury (FOI) in the country in year n;
- GDP_n - national income of the country in year n;
- Cases FOI_n - the number of fatal occupational injury in the country in year n; and
- β₀ is the constant coefficient and the β₁ to β₂ are the coefficients of all independent variables in the regression equation.

Table 1 illustrates the research variables

Table 1. Research variables

Symbol	Variables	Description
Rate FOI	Dependent	Rate of fatal occupational injury
GDP	Independent	National income
Cases FOI	Independent	Cases of fatal occupational injury

3.1 Regression Analysis for Developed Markets

The analysis for developed markets is based on the collected data from the four selected countries, the USA, Norway, Germany, and United Kingdom from 2001 to 2007, and is found in Appendices 4, 5, and 6. As previously discussed, we assess the influence on the rate of fatal occupational injuries from the GDP and the number of cases of fatal occupational injuries in countries with the developed economies by utilizing the developed linear regression model (x). The results in Tables 2, 3 and 4 are derived from regression analysis based the developed model using the statistics found in Appendices 4, 5 and 6.

Table 2. Coefficients^a

Model		Unstandardized coefficients		Standardized	t	Sig.
		B	Std. error	Beta		
1	(Constant)	1.856	.159		11.655	.000
	GDP	-5.162E-13	.000	-1.873	-4.376	.000
	CasesFOI	.002	.000	2.677	6.255	.000

a. Dependent variable: Rate FOI

The linear regression model for developed markets is Rate FOI=1.856 – 5.162E-13 GDP+ 0.002 Cases FOI. In terms of this problem, the above results demonstrate that every dollar of GDP lowers the rate of occupational injury by 0.000000000005162 (5.12E-13) in the country with the developed economy. This relationship is significant because GDP's p-value is 0.000, which is smaller than 5%. At the same time, every case of occupational injury increases the rate of occupational injury by 0.002, and the coefficient for Cases of FOI is statistically significant because its p-value of 0.000 is less than 5%

Table 3. ANOVA^a

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	32.430	2	16.215	60.180	.000 ^b
	Residual	6.197	23	.269		
	Total	38.627	25			

a. Dependent variable: Rate FOI

b. Predictors: (Constant), Cases FOI, GDP

Based on the ANOVA table results for developed markets, the p-value is 0.000, and this value is less than the level of 5%. It tells that if the p-value is smaller than 5%, the independent variables reliably predict the dependent variable

Table 4. Model summary

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.916 ^a	.840	.826	.5191

a. Predictors: (Constant), Cases FOI, GDP

According to the results, 84% of the variation in the rate of fatal occupational injuries is explained by GDP and cases of fatal occupational injuries in the countries with developed economies

The regression analysis demonstrates the positive relationship between the national income and the rate of occupational injury in the developed markets. However, higher GDP and the status of developed countries may provide greater opportunities to invest in safety standards and better enforcement.

3.2 Regression Analysis for Emerging Markets

The analysis for emerging markets is based on the collected data from the four emerging market countries, of Russia, India, Mexico, and Thailand from the years 2001 to 2007, and which are cited in Appendices 1, 2 and 3. We can calculate the influence on the rate of fatal occupational injuries from the GDP and the number of cases of fatal occupational injuries in these four countries by utilizing the developed linear regression model (x). The values found in Tables 5, 6 and 7 are from the regression analysis that is based on the developed model using the statistics found in Appendices 1, 2 and 3.

Table 5. Coefficients^a

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
1	(Constant)	19.036	17.999		1.058	.300
	GDP	4.010E-11	.000	.347	1.794	.085
	Cases FOI	-.005	.007	-.143	-.737	.468

a. Dependent Variable: Rate FOI

The linear regression model for emerging markets is Rate FOI = 19.036 + 4.010E-11 GDP - 0.005 Cases FOI. In terms of this problem, the above results demonstrate that every dollar of GDP increases the rate of occupational injury in the countries with emerging economies by 0.0000000004010 (4.010E-11). The coefficient for GDP in emerging markets is not significantly different from 0 because its p-value is 0.085 or 8.5%, which is larger than 5%. This reverse relationship can be explained by growing the GDP in countries with emerging economies that do not invest in safety standards or enforcement of their standards. At the same time, every case of fatal occupational injury decreases the rate of fatal occupational injury by 0.005. This is statistically insignificant for the rate of fatal occupational injury because Cases of FOI's p-value is 0.468 or 46.8%, which is greater than 5%

Table 6. ANOVA^a

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	4865.165	2	2432.583	1.661	.210 ^b
	Residual	36612.765	25	1464.511		
	Total	41477.930	27			

a. Dependent Variable: Rate FOI

b. Predictors: (Constant), Cases FOI, GDP

Based on the results from the ANOVA table on emerging markets, the p-value is 0.210 (21%) and is greater than 5%, it demonstrates that the group of independent variables does not show a statistically significant relationship with the dependent variable, or that the group of independent variables does not reliably predict the dependent variable

Table 7. Model summary

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.342 ^a	.117	.047	38.2689

a. Predictors: (Constant), Cases FOI, GDP

According to the results, only 12% of the variation in the rate of fatal occupational injuries is explained by both a nation's GDP and its cases of fatal occupational injuries in emerging economy nations

The results of regression analysis demonstrate the national income and the cases of occupational injury in the emerging markets the inverse relationship. It can be explained by under reporting the cases of fatal occupational injury and other factors that have a more direct impact on the rate of fatal occupational injury and implementing safety standards.

4. RESULTS AND DISCUSSION

The results from gathered data in developed and emerging economies can be summarized in Table 8.

Table 8. Summary on occupational injuries in developed and emerging markets

Economy	GDP	Cases of fatal occupational injuries	Rate of fatal injuries
Developed	170 – 14, 991 billion	37 - 5,840	0.6% - 4%
Emerging	120 – 1,400 billion	605 – 4,370	9.0% - 117%

The table details the countries with the developed economies and high national GDP implement have higher safety standards that lead to a lower rate of fatal occupational injuries. On the contrary, countries with the emerging economies and lower national GDP have lower safety standards that lead to higher rate of fatal occupational injuries

The regression analysis provides evidence of a significant relationship between the rate of occupational injury and the level national income (GDP) with the number of cases of fatal occupational injury in countries with developed economies. The insignificant impact on the rate of fatal occupational injury from the level of a nation's GDP and the number of cases of fatal occupational injury was found in countries with emerging economies. This might be explained by underreporting the number of cases of fatal occupational injury and even by the growing level of national income which may necessarily translate into developing and rigorously enforcing safety standards in the nations with emerging markets.

5. CONCLUSION

This analysis shows that there is a significant relationship between safety performance in a society and the level of national income. This further explains the markedly greater occurrence of fatal occupational injuries in nations with emerging economies compared to their developed counterparts. This is very apparent when a country's GDP is lower and its safety standards are substandard or poorly implemented. Countries that have developed economies with higher GDPs have fewer occurrences of fatal occupational injuries and their rate of fatal occupational injury is also lower. This relationship between safety performance in a society and the level of national income is an important consideration for management when it considers outsourcing its manufacturing or any other business overseas. The high risk of fatal occupational injuries might lead to major losses or even a business extinction such as the one that affected like Union Carbide Corporation after the Bhopal disaster.

A limitation of this study is that data for many major players (both developed and emerging) on the global market such as Japan, China, Indonesia, and Bangladesh, was insufficient to be included in this study. The recent safety issues in Bangladesh, for example, have yet to yield publically available data which might have the effect of reinforcing the conclusions of this study.

Future investigation might be focused on other factors that impact the fatal occupational injury occurrences, or other factors that may influence the rate of fatal occupational injury. Perhaps the most fruitful follow-up research will be conducted when data becomes available to the research community to examine the true costs of doing business in nations with lower occupational standards compared with developed economies. The linear regression model had shown a positive relationship on the rate of fatal occupational injury between the countries' GDP and the number of cases of fatal occupational injury in developed economies. Nevertheless, an inverse relationship was revealed among these same factors in emerging economies. This model might be implemented in further testing of causes on the country's rate of fatal occupational injury by expanding it with inclusion of other potential variables for direct relationships. Another vital examination would focus on the apparent anomaly discussed in this work which is the insignificant correlation between the rate of fatal occupational injury from the level of a nation's GDP and the number of cases of fatal occupational injury in nations with emerging economies. Any reason for this discrepancy is an educated guess, but is nevertheless speculative. Reliable data for such a study may be difficult if not impossible to procure. It is also deemed that emerging nations may have substantial degrees of underreporting. They may also have insufficient enforcement of their own standards. These assumptions are also conjecture. As nations become more developed, international norms and standards may encourage emerging economies to enforce safety regulations and accurately and fully report all major accidents, which in turn may lead to more prosperous nations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Appendix 1. GDP in emerging markets

Country	Emerging market						
	GDP						
	2001	2002	2003	2004	2005	2006	2007
Russia	306,602,673,980	345,110,438,694	430,347,770,733	591,016,690,743	764,000,901,161	989,930,542,279	1,299,705,764,824
India	482,967,940,906	504,946,434,158	591,332,373,599	715,459,354,731	837,499,067,126	947,912,052,610	1,206,110,390,294
Mexico	622,092,637,151	649,075,575,302	700,324,664,927	759,777,472,170	848,947,464,609	951,915,698,648	1,036,000,680,567
Thailand	120,051,854,636	134,064,590,967	151,997,909,265	172,637,545,862	188,620,150,176	220,826,400,537	261,825,647,965

This table shows GDP in US dollars for seven years in the selected emerging market countries. Among the selected countries are Russia, India, Mexico, and Thailand. The data were collected from the World Bank Web site [8]

Appendix 2. Cases of fatal occupational injury in emerging markets

Country	Emerging market						
	Cases of fatal occupational injury						
	2001	2002	2003	2004	2005	2006	2007
Russia	4,370	3,920	3,540	3,290	3,090	2,900	2,990
India	1,366	1,346	1,663	1,581	1,780	1,514	2,140
Mexico	1,502	1,361	1,427	1,364	1,367	1,328	1,279
Thailand	605	650	787	861	1,444	808	741

This table shows the number of fatal cases for seven years in the selected emerging market countries. Among the selected countries are Russia, India, Mexico, and Thailand. The data were collected from the International Labor Organization (ILO) Web site [9].

Appendix 3. Rate of fatal occupational injury in emerging markets

Country	Emerging market						
	Rate of fatal occupational injury						
	2001	2002	2003	2004	2005	2006	2007
Russia	15.0%	13.8%	13.1%	12.9%	12.4%	11.9%	12.4%
India	77.9%	87.8%	82.5%	89.3%	133.4%	98.3%	116.8%
Mexico	12.0%	11.0%	12.0%	11.0%	11.0%	10.0%	9.0%
Thailand	10.9%	9.9%	11.2%	11.7%	18.7%	10.1%	9.1%

This table shows the rate of fatal cases for seven years in the selected emerging market countries. Among the selected countries are Russia, India, Mexico, and Thailand. The data were collected from the International Labor Organization (ILO) Web site.

Appendix 4. GPD in developed markets

Country	Developed market						
	GDP						
	2001	2002	2003	2004	2005	2006	2007
USA	10,233,900,000,000	10,590,200,000,000	11,089,300,000,000	11,797,800,000,000	12,564,300,000,000	13,314,500,000,000	13,961,800,000,000
Norway	170,922,851,074	191,927,027,230	224,880,794,328	260,029,106,208	304,060,069,849	340,041,912,704	393,479,162,082
Germany	1,880,878,023,463	2,006,678,890,909	2,423,721,432,864	2,726,341,472,500	2,766,253,792,966	2,902,749,305,068	3,323,809,686,746
Unites Kingdom	1,468,121,585,535	1,601,561,196,401	1,855,750,258,175	2,196,860,009,521	2,295,843,320,737	2,452,970,940,716	2,825,528,324,602

This table shows GDP in US dollar for seven years in the selected developed economies. Among the selected countries are USA, Norway, Germany and United Kingdom. The data were collected from the World Bank Web site

Appendix 5. Cases of fatal occupational injury in developed markets

Country	Developed market						
	Cases of fatal occupational injury						
	2001	2002	2003	2004	2005	2006	2007
USA			5,575	5,764	5,734	5,840	5,657
Norway	37	39	49	38	48	31	38
Germany	1,107	1,071	1,029	949	863	941	812
Unites Kingdom	210	191	174	179	173	220	

This table shows the number of fatal cases for seven years in the selected developed economies. Among the selected countries are USA, Norway, Germany, and United Kingdom. The data were collected from the International Labor Organization (ILO) Web site. Data is missing from 2001 and 2002 from the U.S. and from 2007 for the United Kingdom due to the absence on provided information to the International Labor Organization

Appendix 6. Rate of fatal occupational injury in developed markets

Country	Developed market						
	Rate of fatal occupational injury						
	2001	2002	2003	2004	2005	2006	2007
USA			4%	4%	4%	4%	4%
Norway	1.6%	1.7%	2.1%	1.3%	2.1%	1.3%	1.6%
Germany	3%	2.9%	2.8%	2.6%	2.4%	2.5%	2.2%
Unites Kingdom	0.8%	0.7%	0.7%	0.7%	0.6%	0.7%	

This table shows the rate of fatal cases for seven years in the selected developed economies. The selected countries are USA, Norway, Germany, and United Kingdom. The data were collected from the international labor organization (ILO) web site. Data is missing from 2001 and 2002 from the U.S. and from 2007 for the United Kingdom due to the absence on provided information to the international labor organization

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