The Relationship between National Income and Occupational Injury

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.

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 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 Fukuhima 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

42 national income and occupation injury which may be empirically assumed is strongly verified
43 by the data presented.
44
45 **2. LITERATURE REVIEW**
46
47 The key purpose of this study is to understand the core reasons of man-made accidents.
48 Various researchers have studied similar questions to the one posed here. Khazai, Merz,
49 Schulz, & Borst have used   a framework to describe a regions exposure to indirect disaster
50 losses.   This proposed framework enables the combination of sub-systems including
51 industrial and social ones and identifies a regions vulnerability to losses. It further exposes
52 the characteristic fragilities of the region and the coping capacities of the people within
53 affected areas to deal with such damages. An advantage of this indicator-based approach is
54 that it can be widened to include the vulnerably of other sub-systems such as Agricultural or
55 Ecological.   One of the key advantages of this technique is that it can identify the most
56 vulnerable regions and even rank different regions as to their susceptibility. This in turn can
57 lead to better planning and implement the most cost effective mitigation measures. The
58 model is implemented through multi-criteria decision analysis software [2].
59
60 A study by Park (2011) has recognized a set of statistically significant relationships which
61 quantifies the variables that determine the safety performance of a society. The findings
62 largely confirm the inverted *u*-curve or Safety Kuznet curve. This hypothesis identifies the
63 relationship between the safety performance in a society and its level of national income.
64 These findings have some potential implications. The first is for the policy makers in nations
65 that show a higher potential for man-made disasters. Included among these are the rapidly
66 growing economies and newly industrialized countries such as China and India.   The
67 repeated mining accidents in China, for example, are likely the result of failure to
68 comprehend the root cause of the disasters. The other major implication is for multinational
69 insurance companies. They need to exhibit extra caution for those countries that are at
70 higher risk, and they can develop a better strategy which may be more culturally sensitive
71 but may have a justifiably higher premium due to greater risk [3].
72
73 What may be the worst industrial disaster ever, may have resulted, according to recently
74 released documents, from the attempt to reduce operating costs which led Union Carbide
75 India Limited (UCIL) to cost cutting design flaws according to MacKenzie. The disaster which
76 occurred at the pesticide plant in Bhopal, India on December 2–3, 1984 resulted in about
77 8,000 people killed and another 150,000 injured [4].
78
79 The central thesis of an investigation by Saaroni is that while the risk of disaster may be
80 mitigated, not all disasters can be prevented. The very concept of risk itself is based on
81 human perception and may not account for the infinite and unknown number of possible
82 variables. It is not possible to find all risk factors that may result in industrial disasters. In
83 those instances where crucial risks are identified, they still may not be manageable in an
84 industrial setting which is usually a complex system. A further complication is that industrial
85 complexes are created and run by humans. This alone puts doubt into industrial disaster
86 prevention. Other factors such as environmental factors and conflict may also avert industrial
87 disaster prevention [5].
88
89 Passariello reported in the Wall Street Journal that well-known American and Western
90 retailers became part of factory disaster legacy of Bangladesh in 2012 and 2013. Tazreen
91 Fashion Limited violated fire safety rules that resulted in tragedy affecting a great number of
92 employees and their family. Tazreen Fashion Limited was making clothes for Walmart and
93 Sears. Liberty Fashion Wears Ltd had structural failures at their facility, and the Rana Plaza
94 Factory also had a structural fault that led to a collapsed building.   With these

aforementioned industrial disasters, many famous retailers associate, such as Hennes & 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.
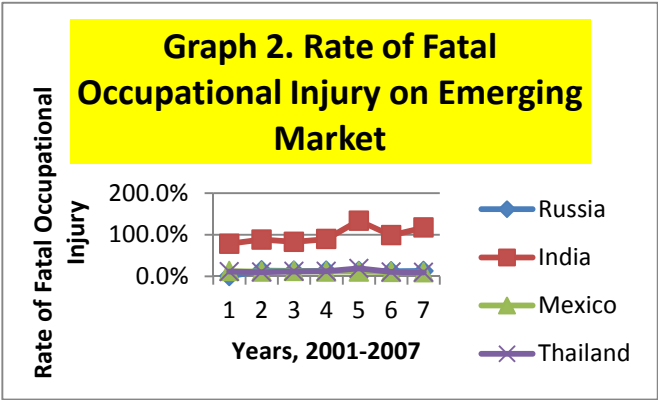
Graph 1. Factors Influence on Rate of Fatal Occupational Injury

HIGH

Low GDP   Low Standards

National income
(GDP)

Rate of Fatal
Occupational Injury

Safety Standards

High GDP   High Standards

LOW
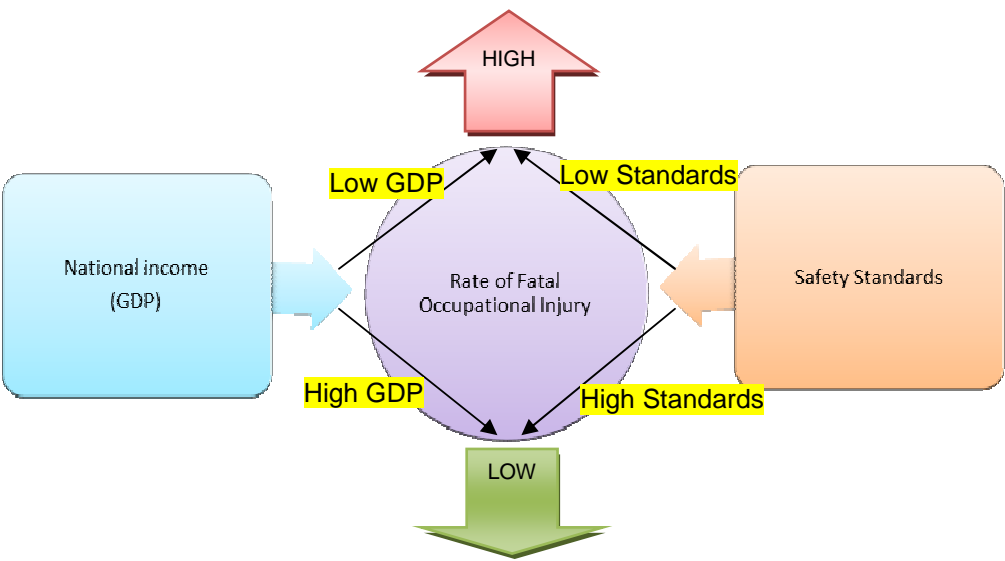
149
150
151
152
153
154
155
156

157   The trend of emerging and developed markets from 2001 through 2007 demonstrates that
158   GDP is much higher in the developed economies than in emerging markets. Countries with
159   the developed economies have GDP higher than $2 trillion. On the other hand, countries
160   from the emerging market have GDP lower than $2 trillion.
161
162   The rate of Fatal Occupational Injury in emerging market are higher, ranging from 10% to
163   117% compared to developed economies of only 0.6% - 4% (referring to graph 2 and 3).
164

**Graph 2. Rate of Fatal
Occupational Injury on Emerging
Market**

Rate of Fatal Occupational Injury

200.0%
100.0%
0.0%

1 2 3 4 5 6 7
Years, 2001-2007

Russia
India
Mexico
Thailand

165
166

167 *The rates for Russia, Mexico and Thailand are similar.* ==*The trend for India is significantly*==
168 ==*higher, compared to Russia, Mexico, and Thailand.*==
169

Graph 3. Rate of Fatal Occupational Injury on Developed Market

Rate of Fatal Occupational Injury

5%

0%

1 2 3 4 5 6 7

Years, 2001-2007

◆ USA

■ Norway
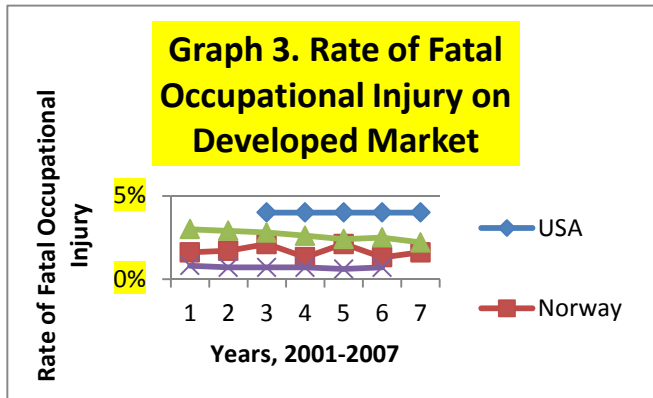
170
171
172 *The rates for the four developed economies range from less than 1% to about 4%.*
173
174 To assess the relationship between a dependent (rate of fatal occupational injuries in this
175 study) and independent variables (the GDP and the number of cases of fatal occupational
176 injuries), this study incorporates a descriptive-correlation. This relationship between
177 variables requires implementing a linear regression. The results are evaluated based on the
178 Fisher F test, by utilizing SPSS software. The significance of the independent variables are
179 assessed when the Fisher F statistic is less than 5% (Sig F <5%).
180
181 The following linear regression model (1) is used to test the hypotheses:
182
183 $FOI_n = \beta_0 + \beta_1 * GDP_n + \beta_2 * Cases\ FOI_n$ (x)
184
185 • FOI_n - the rate of fatal occupational injury (FOI) in the country in year n;
186 • GDP_n - national income of the country in year n;
187 • $Cases\ FOI_n$ - the number of fatal occupational injury in the country in year n; and
188 • β_0 is the constant coefficient and the β_1 to $\beta2$ are the coefficients of all independent
189   variables in the regression equation.
190
191 Table 1 illustrates the research variables:
192
193   **Table 1. Research Variables**

Symbol	*Variables*	*Description*
Rate of FOI	Dependent	Rate of Fatal Occupational Injury
GDP	Independent	National Income
Cases FOI	Independent	Cases of Fatal Occupational Injury

194

195
196
Regression Analysis for Developed Markets

Table 2. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	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: RateFOI

The linear regression model for developed markets is $Y = 1.856 - 5.162E\text{-}13\,\beta_1 + 0.002\,\beta_2$. In terms of this problem, the above results demonstrate that an increase in the rate of occupational injury in the country with the developed economy is explained by the reduction of its national income by $5.16 billion. At the same time, an increase in the rate of occupational injury is explained by the growing number of cases of occupational injury by 0.002.

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: RateFOI

b. Predictors: (Constant), CasesFOI, 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), CasesFOI, GDP

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

201

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

206

207 # Regression Analysis for Emerging Markets

208

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
	CasesFOI	-.005	.007	-.143	-.737	.468

a. Dependent Variable: RateFOI

209 *The linear regression model for emerging markets is $Y=19.036+4.010E\text{-}11\ \beta_1 - 0.005\ \beta_2$. In*
210 *terms of this problem, the above results demonstrate that an increase in the rate of*
211 *occupational injury in the countries with emerging economies is explained by the increase of*
212 *its national income (GDP) by $4.010 billion. At the same time, an increase in the rate of*
213 *occupational injury is explained by the decreasing number of cases of occupational injury by*
214 *0.005. Previous results from the ANOVA table tell this relationship is insignificant.*

215

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: RateFOI

b. Predictors: (Constant), CasesFOI, GDP

216

217 Based on the results from the ANOVA table on emerging markets, the p-value is 0.210
218 (21%) and is greater than 5%, it demonstrates that the group of independent variables does
219 not show a statistically significant relationship with the dependent variable, or that the group
220 of independent variables does not reliably predict the dependent variable.

221

Table 7. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.342[a]	.117	.047	38.2689

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.

3. RESULTS AND DISCUSSION

The results from gathered data in developed and emerging economies can be summarized in the following form:

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.

4. 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.

REFERENCES

1. Smith, A. (2011). Fukushima evacuation has killed more than earthquake and tsunami, survey says. Retrieved from http://www.nbcnews.com/#/news/other/fukushima-evacuation-has-killed-more-earthquake-tsunami-survey-says-f8C11120007

2. Khazai, B. , Merz, M. , Schulz, C. , & Borst, D. (2013). An integrated indicator framework for spatial assessment of industrial and social vulnerability to indirect disaster losses. Natural Hazards, 67(2), p. 145-167.

3. Park, H. (2011). Man-made disasters: A cross-national analysis. International Business Review, 20(4), p. 466-476.

4. MacKenzie, D. (2002). Fresh evidence on Bhopal disaster. New Scientist, 176(2372), p. 6.

5. Saaroni, L. (2011). Are all industrial disasters preventable? Retrieved from http://www.academia.edu/1115891/Are_all_industrial_disasters_preventable

6. Passariello, C. (2013). Retailers Speed Up Bangladesh Rules. The Wall Street Journal, July 8, p. B1, B6.

7. Mihailidou, E.K., Antoniadis, K.D., & Assael, M.J. (2012). The 319 Major Industrial Accidents Since 1917. International Review of Chemical Engineering, 4 (6), p.529-540.

321
322   8. The World Bank. (2013). Gross Domestic Product 1970-2011. Retrieved from
323   http://databank.worldbank.org/data/download/GDP.pdf
324
325   9. The International Labor Organization. (2013). ILOSTAT Database by country. Retrieved
326   from http://www.ilo.org/ilostat/faces/home/statisticaldata/data_by_country?_adf.ctrl-
327   state=ol8mmij5r_4&_afrLoop=501912095944467
328

329 **APPENDIX**

330

331

332 Appendix 1: GPD in Emerging Markets

333

Emerging Market							
Country	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

334

335 *This table shows GDP in US dollars for seven years in the selected emerging market countries. . Among the selected countries are Russia,*
336 *India, Mexico, and Thailand. The data were collected from the World Bank Web site [7].*

337

338

339 Appendix 2: Cases of Fatal Occupational Injury in Emerging Markets

340

Emerging Market							
Country	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

341

342 *This table shows the number of fatal cases for seven years in the selected emerging market countries. Among the selected countries are*
343 *Russia, India, Mexico, and Thailand. The data were collected from the International Labor Organization (ILO) Web site [8].*

344   Appendix 3: Rate of Fatal Occupational Injury in Emerging Markets
345

Emerging Market							
Country	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%

346
347   *This table shows the rate of fatal cases for seven years in the selected emerging market countries. Among the selected countries are*
348   *Russia, India, Mexico, and Thailand. The data were collected from the International Labor Organization (ILO) Web site.*
349
350
351
352
353   Appendix 4: GPD in Developed Markets
354

Developed Market							
Country	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

355
356
357   *This table shows GDP in US dollar for seven years in the selected developed economies. Among the selected countries are USA, Norway,*
358   *Germany, and United Kingdom. The data were collected from the World Bank Web site.*

359 Appendix 5: Cases of Fatal Occupational Injury in Developed Markets
360

Developed Market							
Country	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	

361
362 *This table shows the number of fatal cases for seven years in the selected developed economies. Among the selected countries are USA,*
363 *Norway, Germany, and United Kingdom. The data were collected from the International Labor Organization (ILO) Web site. Data is*
364 *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*
365 *International Labor Organization.*
366
367
368 Appendix 6: Rate of Fatal Occupational Injury in Developed Markets
369

Developed Market							
Country	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%	

370
371 *This table shows the rate of fatal cases for seven years in the selected developed economies. The selected countries are USA, Norway,*
372 *Germany, and United Kingdom. The data were collected from the international labor organization (ILO) web site. Data is missing from*

373   *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*
374   *organization*