APPENDIX A
Assessment of Global Cost of Corrosion

A.1 INTRODUCTION

The purpose of the "cost of corrosion" portion of the IMPACT Study is to establish a cost of corrosion at a global level utilizing past studies. The current study did not attempt to collect new raw data and perform any new cost of corrosion analysis. Therefore, the cost of corrosion performed within the IMPACT Study is limited by the completeness and number of available studies.

A.2 HISTORIC PERSPECTIVE

Since the 1950's several countries considered the economic consequences of corrosion. Studies conducted during this time indicated that the cost of corrosion to society was significant. The different approaches used to arrive at the Cost of Corrosion included:

- The Uhlig method, which defines corrosion cost as the total expenditure by manufacturing industries and corrosion-protection measures. [See Section A.2.1 for more details.]
- The Hoar method, which estimates corrosion costs for individual industrial sectors, taking account of both direct corrosion cost and spending on countermeasures. In addition to operational costs, cost of capital can also be included. [See Section A.2.3 for more details.]
- The input/output economic model, used in the 1970's Battelle study[1,2],which uses domestic commercial interactions among industries. In this model, the gross domestic product (GDP) is calculated under the assumption of three universes:
    - (Universe I) Actual world with corrosion.
    - (Universe II) Imaginary world with no corrosion.
    - (Universe III) Ideal world with inhibited corrosion.

  The GDP for each universe is calculated, and then the corrosion cost and avoidable corrosion cost are calculated by:
    - Corrosion cost = GDP (Universe II) – GDP (Universe I).
    - Avoidable corrosion cost = GDP (Universe III) – GDP (Universe I).

NBS estimated that the uncertainty of this method is 30 percent.

A.2.1 United States (1949): The Uhlig Report

The 1949 study, "The Cost of Corrosion in the United States" led by H.H. Uhlig[3] was the earliest effort to estimate the costs of corrosion. The annual cost of corrosion to the United States was estimated to be $5,500,000,000 (USD5.5 billion) or equivalent to 2.1 percent of the 1949 gross national product (GNP).[4] Assuming a GDP of USD220 billion for 1949,[5] the cost of corrosion is equivalent to 2.5 percent of the GDP. This study measured the total costs by summing up the cost for (i) the owner / operator and (ii) the users of corroding components. The cost for the owners/ operators was estimated by

1 Economic Effects of Metallic Corrosion in the United States, NBS Special Publication 511-1, SD Stock No. SN-003-003-01926, 1978

2 Economics Effects of Metallic Corrosion in the United States, Appendix B, NBS Special Publications 511-2, SD Stock No. SD-003-003-01926-5, 1978

3 H.H. Uhlig, "The Cost of Corrosion to the United States," Chemical Engineering News, Vol. 27, p 2764, 1949; or Corrosion, Vol. 6, p 29, 1950.

4 GNP was used in original study.

5 U.S. Bureau of Economic Analysis

summing up cost estimates for corrosion prevention products and services used in the entire U.S. economy (for example, coatings, inhibitors, corrosion-resistant metals and cathodic protection). The cost for private consumers/users was evaluated as costs due to select services (domestic water heater replacement, automobile internal combustion engine repairs, and replacement of automobile mufflers). An advantage of the method is that the cost data are more readily available for well-defined products and services. The disadvantage is that several costs can be left out including other operational costs and costs of capital due to corrosion of assets.

A.2.2 West Germany (1969)

West Germany conducted a study of corrosion costs at the end of the 1960s.[6] The total cost of corrosion was estimated to be 19 billion Deutschmarks (DM) (USD6 billion) for the period of 1968 to 1969. Of this cost, 4.3 billion DM (USD1.5 billion) was estimated to be avoidable. This gave a total cost of corrosion equivalent to approximately 3 percent of the West German GNP for 1969 (equivalent to 2.8% of estimated GDP (USD215 billion) in 1970)[7] and avoidable costs were estimated to be 25 percent of total corrosion costs. There was no detailed information separating the corrosion cost into economic sectors.

A.2.3 United Kingdom (1970): The Hoar Report

In March 1966, the U.K. Committee on Corrosion Protection was established by the U.K. Minister of Technology under the chairmanship of T.P. Hoar. In 1970, the committee issued its report entitled "Report of the Committee on Corrosion and Protection".[8] The committee summarized its findings as follows: "*We conservatively estimate the cost of corrosion as £1,365 million per annum, which represents 3.5 percent of the gross national product of 1970. We believe that a saving of approximately £310 million per annum could be achieved with better use of current knowledge and techniques*." This represents savings of approximately 23 percent of the total national corrosion costs.

The Hoar report determined the cost of corrosion for industry sectors of the economy. The cost of corrosion for each industry sector was subsequently added together to arrive at an estimate of total cost of corrosion for the whole U.K. economy. The Industry Sectors included: Building and Construction, Food, General Engineering, Government Departments and Agencies, Marine, Metal Refining and Semi-Fabrication, Oil and Chemical, Power, Transport, and Water. Information was gathered by interviewing corrosion experts who worked in companies and agencies and by surveys on expenditures for corrosion protection practices. Corrosion experts estimated corrosion costs and the potential savings based on their experiences with major economic sectors.

A.2.4 Japan (1974)

Japan conducted a survey of the cost of corrosion to its economy in 1977 through the Committee on Corrosion and Protection.[9] The committee was chaired by G. Okamoto and was organized by the Japan Society of Corrosion Engineering and the Japan Association of Corrosion Control. Support for the study came from the Ministry of International Trade and Industry. The survey determined that the annual

6 D. Behrens, Br. Corrosion Journal, Vol. 10, Issue 3, p. 122, 1967.

7 http://macroeconomics.kushnirs.org/index.php?area=germany&indicator=gdp&lang=en.

8 Report of the Committee on Corrosion and Protection – A Survey of Corrosion Protection in the United Kingdom, Chairman T.P. Hoar, 1971.

9 Report of the Committee on Corrosion and Protection – A Survey of the Cost of Corrosion to Japan, Japan Society of Corrosion Engineering and Japan Association of Corrosion Control, Chairman G. Okamoto, 1977.

cost of corrosion to Japan was approximately 2.5 trillion yen (USD9.2 billion) in 1974. Estimating Japan's GDP at USD472 billion for 1974, the cost of corrosion was the equivalent of 2.0 percent of Japan's 1974 GDP.

A.2.5 United States (1975): The Battelle – NBS Report

In response to a Congressional Directive, the National Bureau of Standards [NBS, now the National Institute of Standards and Technology (NIST)] studied the cost of metallic corrosion in the United States using Battelle Columbus Laboratories (Battelle) to perform the analysis. The results of this work were presented in two reports and a series of publications in Materials Performance.[1,2,10] The Battelle-NBS study was the first to combine the knowledge of corrosion and economics experts to determine the economic impact of corrosion on the U.S. economy. The study used a version of the Battelle National Input/Output Model to estimate the total corrosion cost. This model quantitatively identified corrosion-related changes in the resources (i.e., materials, labor, and energy), changes in capital equipment and facilities, and changes in the replacement lives of capital items for entire sectors of the economy. The input/output model is able to account for both the direct effects of corrosion on individual sectors and the interactions among various sectors.

The final results of the Battelle-NBS study, after adjustments by NBS to the Battelle report, for the base year of 1975 were: (i) the total U.S. cost of metallic corrosion per year was estimated to be USD70 billion, which is equivalent to 4.5 percent of the GDP in 1975 (USD1,549 billion), and (ii) 14 percent or USD10 billion was estimated to be avoidable by the use of the most economically effective, presently available corrosion technology.

A.2.6 Australia (1982)

In 1982, the Commonwealth Department of Science and Technology commissioned a study to determine the feasibility of the establishment in Australia of a National Center for Corrosion Prevention and Control. The feasibility study included a determination of the annual cost of corrosion to Australia. The results were presented in a 1983 report entitled "Corrosion in Australia – The Report of the Australian National Centre for Corrosion Prevention and Control Feasibility Study".[11]

The study concluded that the annual cost of corrosion to the Australian economy was AUD2 billion at 1982 prices, approximately 1.5 percent of Australia's GNP in 1982 (equivalent to 1.0 percent of the GDP (estimated at AUD196 billion)).[12] The report indicated that improved technology transfer and implementation could potentially recover a large portion of the corrosion costs. Furthermore, it was noted that the value of the savings to the Australian community from improved corrosion control would make a worthwhile contribution to the nation's economy.

A.2.7 Kuwait (1987/1992)

In 1992, Kuwait conducted an economic assessment of the total cost of corrosion to its economy using a modified version of the Battelle-NBS IO model.[13] The base year study (1987) gave a total cost of

10 J.H. Payer, W.K. Boyd, D.G. Lippold, and W.H. Fisher, "NBS-Battelle Cost of Corrosion Study ($70 Billion!)," Part 1-7, Materials Performance, May-November 1980.

11 B.W. Cherry and B.S. Skerry, Corrosion in Australia – The Report of the Australian National Centre for Corrosion Prevention and Control Feasibility Study, 1983.

12 http://macroeconomics.kushnirs.org/index.php?area=australia&indicator=gdp&lang=en.

13 F. Al-Kharafi, A. Al-Hashem, and F. Martrouk, Economic Effects of Metallic Corrosion in the State of Kuwait, Final Report No. 4761, KISR Publications, December 1995.

corrosion estimated at USD1 billion (1987 dollars), equivalent to 5.2 percent of Kuwait's 1987 GDP. Avoidable corrosion costs were estimated at USD180 million or 18 percent of the total cost.

On the sector level, the estimates for total cost of corrosion in the oil sectors (crude petroleum and petroleum refining) were USD60 million in 1987. The avoidable cost in these sectors was estimated to be USD10 million. The commercial services sector, the government, and the social and household services sectors were responsible for the largest share (70 percent) of the total cost of corrosion.

A.2.8 Japan (1997)

In 1999, 25 years had passed since the prior 1974 study, and the industrial structure in Japan had changed. Correspondingly, the Committee on the Cost of Corrosion in Japan was organized in 1999 jointly by the Japan Society of Corrosion Engineering (JSCE) and the Japan Association of Corrosion Control (JACC) to update the cost of corrosion.[14] The project was funded by the National Research Institute for Metals (NRIM) as part of the Ultra-Steels (STX-21) Project.

Cost of corrosion in 1997 was estimated by the Uhlig method and the Hoar method. In addition to the above estimation, a preliminary analysis by the Input/Output method was performed to estimate the total cost of corrosion including the direct and indirect costs. The overall corrosion related cost estimated by the Uhlig and Hoar methods were 3,938 billion yen and 5,258 billion yen, respectively, which were equivalent to 0.77 percent and 1.02 percent of the 1997 GNP (converting to GDP (560,993 billion yen in 1997) [15], the cost of corrosion is equivalent to 0.70 and 0.94 respectively). The total cost including the direct and indirect costs, which were estimated by the Input/Output analysis, was equivalent to 1.88 percent of the 1997 GNP (1.73 percent of GDP). The value for the Input/Output economic model for 1997 is similar to the 1974 cost of corrosion, i.e. equivalent to 1.8 percent of the GDP.

The GNP and GDP analyses gave similar values for the percent cost of corrosion (especially when considering the conversions used to estimate the GDP) and since the Hoar method provided a division by Sectors, the Hoar method values were used in the global cost of corrosion analysis.

14 "Survey of Corrosion Cost in Japan", Committee on Cost of Corrosion in Japan, 1997.

15 http://macroeconomics.kushnirs.org/index.php?indicator=gdp&area=japan&lang=en.

A.2.9 United States (1998): The FHWA Report

In 1998, the US Congress approved an amendment to the Transportation Equity Act for the 21st Century to conduct a Cost of Corrosion study.[16] This study was funded through the Federal Highway Administration (FHWA) and performed by CC Technologies, Inc. (now part of DNV GL) partnering with NACE International, and Professor Joe Payer. This project used a combination of the Uhlig and Hoar methods with inclusion of significant expert knowledge input.

The total direct cost of corrosion was estimated at $276 billion per year, which is 3.1 percent of the 1998 U.S. GDP. This cost was determined by analyzing 26 industrial sectors in which corrosion is known to exist and extrapolating the results for a nationwide estimate. The sectors were divided among five major categories: infrastructure, utilities, transportation, production and manufacturing, and government. The indirect cost of corrosion was conservatively estimated to be equal to the direct cost (i.e., total direct cost plus indirect cost is 6 percent of the GDP). Social cost (lost time and productivity of the general public due to delays and business interruption caused by corrosion and corrosion control activities) was the primary indirect cost considered. It was found that the sectors of drinking water and sewer systems (USD36 billion), motor vehicles (USD23.4 billion), and defense (USD20 billion) had the largest direct corrosion impact. A total of USD121 billion per year was spent on corrosion control methods and services.

A.2.10 Australia (2010)

The Australasian Corrosion Association (ACA) in conjunction with industry experts performed a project to (i) examine, identify and estimate corrosion failure costs attributable to industry practices, industry skilling and regulatory frameworks, and (ii) estimate potential corrosion failure cost reductions by implementing avoidable/preventable strategies within the water transportation, processing and sewage industry in Australia.[17]

The study included: water loss from pipeline leakage, water loss from pipeline failures, intangible costs associated with water and sewer pipe failures and replacements, water pipeline corrosion repairs, sewer pipeline corrosion repairs, sewage treatment costs due to infiltration, capital cost for water and sewer pipeline replacements, maintenance and repair water treatment plants, maintenance and repair of other assets (tanks, pump stations etc.), and maintenance and repair sewage treatment plants. This approach gave a total cost of corrosion of water and sewer industry of AUD981.67 million. Although this study provided a detail cost of one industry sector, this could not be used in the IMPACT cost of corrosion study, which requires a more detailed national cost of corrosion.

16 "Corrosion Cost and Preventive Strategies in the United States", FHWA-RD-01-156, G. Koch, M. Brongers, N. Thompson, P. Virmani, and J. Payer, March 2002.

17 "The Australian Corrosion Association Inc. Corrosion Challenge Project", November 2010

A.2.11 India (2011-2012)

In a study led by R. Bhaskaran at Lovely Professional University, Phagwara, Punjab, India and N.S. Rengaswamy at Central Electrochemical Research Institute, Karaikudi, India, the cost of corrosion was estimated using the NBS input/output economic model for 2011 to 2012.[18]

The India study gave one of the most detailed sector breakdowns of any of the national costs of corrosion. The direct cost of corrosion for India was USD26.1 billion or 2.4 percent of India GDP. The avoidable cost of corrosion was USD9.3 billion or 35 percent of the direct cost of corrosion. The indirect cost of corrosion was USD39.8 billion or 3.6 percent of India GDP. Several of the indirect cost of corrosion for the India study (input/output model) were classified as direct costs in the 1998 United States study (Hoar method). These include: loss of product, loss of efficiency, and production loss; only social costs were classified as indirect costs in the United States study. If only the social costs are classified as indirect costs, the direct cost of corrosion in India is 4.5 percent.

A.3 IMPACT COST OF CORROSION ANALYSIS

Since various geographic regions differ in the proportion of different economic sectors in their economy, to relate the above cost of corrosion studies to a global cost of corrosion, a relationship between economic sectors and corrosion costs is needed. Furthermore, the GDP of the economic sectors by country must be known to permit the use of the "percent cost of corrosion by economic sector" within the extrapolation to global corrosion costs. For instance, those studies that provide only a total input/output model cost of corrosion for the whole country do not permit a global cost of corrosion based on an economic sector analysis.

Considering the data in the available studies, the economic sectors used in this analysis were (1) Agriculture, (2) Industry, and (3) Services. For each of these Sectors, (1) the cost of corrosion was estimated by summing the costs of the appropriate sub-sectors for a given study and (2) the GDP for every nation globally divided into these Sectors was available from the World Bank data[19].

The studies that were included in the IMPACT cost of corrosion Study were: India 2011-2012, United States 1998, Japan 1997, Kuwait 1987, and United Kingdom 1970. Each of these studies provided data that could be divided into the three economic sectors discussed above.

As previously mentioned, several other studies produced a cost of corrosion associated with the total annual GDP; the GDP and cost of corrosion was not divided into sectors. These studies included Saudi Arabia, United Arab Emirates, Oman, Qatar, Bahrain, Australia and Columbia. Therefore, these studies could not be included in the Sector analysis of cost of corrosion.

18 "An Analysis of the Updated Cost of Corrosion in India", Materials Performance, Vol. 53, No. 8, pp. 56-65

19 The World Fact Book, GDP – Composition, by Sector of Origin (%), https://www.cia.gov/library/publications/the-world-factbook/fields/2012.html

A.4 DEFINITION OF 'GROSS DOMESTIC PRODUCT – GDP'

The GDP was used for the IMPACT cost of corrosion global analysis, because it permits the summing of GDPs of multiple countries to provide an aggregate GDP for a given analysis. In addition, the GDPs for all countries were available along with the division of GDP into economic sectors.

The GDP of the three economic Sectors (Agriculture, Industry, and Services) is the basis for extrapolating the cost of corrosion from six countries (those with detailed cost of corrosion analyses) to a global cost of corrosion. GDP is the monetary value of all the finished goods and services produced within a country's borders in a specific time period, although GDP is usually calculated on an annual basis.[20] It includes all private and public consumption, government outlays, investments and exports less imports that occur within a defined territory.

$$\mathbf{GDP = C + G + I + NX}$$

where:

"**C**" is equal to all private consumption, or consumer spending, in a nation's economy; "**G**" is the sum of government spending; "**I**" is the sum of all the country's businesses spending on capital; and "**NX**" is the nation's total net exports, calculated as total exports minus total imports (NX = Exports - Imports).

A.5 SECTOR BREAKDOWN

Economic breakdown by sector can be performed in multiple ways: (1) sectors of primary importance to a given technology (e.g. NACE International has technical committees broken down by industries), (2) sectors consistent with prior studies (e.g. Sectors from the 2002 FHWA report "Corrosion Cost and Preventive Strategies in the United States"), (3) sectors determined by a committee of subject matter experts, or (4) sectors based on the World Bank data. To facilitate comparison of studies, it was decided to utilize the World Bank international categorization of the GDP[15] with some modification to permit mapping and provide as much detail as possible. Each study used was mapped into the Sector list given in Table A-1.

The World Bank measures a countries' GDP by breaking the GDP into three primary sectors referred to as Level 1 in Table A-1: Agriculture, Industry, and Services. Each Level 1 Sector was subdivided into subcategories (Levels 2 and 3). Green shade indicates the three primary Sectors of the GDP, pink represents the Level 2 subcategories and no shading represents the Level 3 subcategories. World Bank sub-sectors are denoted by letters A to S in front of the category name (the majority of these were Level 2 with N, O, P, and Q placed under a Level 2 heading of "Community, Social and Personal Services".

20 http://www.investopedia.com/terms/g/gdp.asp#ixzz3dEila2AG

Table A-1. Breakdown of Sectors

Level 1	**Level 2**	Level 3
Agriculture & Allied Activities	**A. Agriculture, Forestry & Fishing**	
Industry	**B. Mining & Quarrying**	Petroleum & Natural Gas
		Other Mining
	C. Manufacturing	Non-metallic products
		Metal products & Basic Metal Industries
		Electrical machinery
		Transport equipment
		Chemicals, etc.
		Petroleum Refining and other related products
		Paper & Printing, etc.
		Food products, Beverages & Tobacco
		Other manufacturing (General)
	F. Construction	New Construction
		Repair & Maintenance
	D. Electricity, Gas, Steam, & AC Supply	Gas (icl. distribution pipelines)
		Electricity, Power Generation, Transmission
	E. Water Supply, Sewage, Waste Management & Remediation	
Services	**I. Accommodation & Food Service Activities**	
	H. Transportation & Storage	Rail transport, Trains
		Road transport, Automobiles
		Water transport, Ships, Marine
		Air transport
		Transmission Pipelines
		Power Transmission
		Waterways & Ports
		Hazardous Material Transport
		Transportation Services
		Highway Bridges
		Storage
	J. Information & Communication	
	K. Financial & Insurance Activities	Real Estate
		Legal Services
	G. Wholesale and retail trade	
	R. Arts, Entertainment & Recreation	
	M. Professional, Scientific & Technical Activities	
	S. Other Service Activities	
	Community, Social & Personal Services	N. Administrative & Support Services Activities
		O. Public Administration & Defense; Social Security
		P. Education
		Q. Human Health & Social Work Activities

A.6 RESULTS

A.6.1 Summary Cost of Corrosion Studies

Table A-2 presents the cost of corrosion as an equivalent percentage of the GDP for the countries that have performed studies. Several of the countries noted performed the input/output model and reported only a total cost of corrosion with no sector breakdown.

Table A-2. Cost of Corrosion Summary for Countries (percentage of the GDP)

Study	Agriculture %CoC	Industry %CoC	Services %CoC	Total %CoC
Saudi Arabia 2011* [21]				2.7
Kuwait 2011*[18]				1.7
United Arab Emirates 2011*[18]				1.3
Oman 2011*[18]				1.8
Qatar 2011*[18]				0.7
Bahrain 2011*[18]				2.1
Columbia 1993[22]				2.4
Australia 1982*[11]				1.5
United States 1998 [16]	1.1	9.3	1.3	3.1
India 2011** [18]	6.1	4.7	3.4	4.5
Japan 1974*** [9]				1.8
Japan 1997 [14]		3.6	0.1	1.0
United Kingdom 1970 [8]		8.6	2.2	3.5
Kuwait 1987 [13]	9.5	2.2	8.3	5.2

Note: * Input output model with only the total cost of corrosion provided.
** Based on indirect cost of corrosion other than social costs included in "cost of corrosion".
*** The Hoar method was used instead of the Input/Output method because Sector information was available from the Hoar method. In addition the GNP and estimate for GDP were similar.

A.6.2 Sector Cost of Corrosion

For national cost of corrosion studies to be used in an economic sector analysis, the study itself had to include sector details. For the purpose of this study, the individual study sector detail was mapped to the Sectors given in Table A-2. The following studies had the necessary sector detail (although the level of detail varied) and were used in the IMPACT cost of corrosion Global analysis:

- India 2011-2012.
- United States 1998.
- Japan 1997.
- Kuwait 1987.

21 "Corrosion in the Gulf Cooperation Council (GCC) States: Statistics and Figures", A. Al-Hashem.

22 "A System Approach for Estimating Corrosion Incidence to the Economy of a Nation", 1994 International System Dynamics Conference, R. Sotaquira, et al., 1994.

- United Kingdom 1970.

Table A-3 through Table A-7 provide the Sector detail for the individual studies.

Table A-3. Cost of Corrosion by Sector for India 2011-2012 study

Sector	*CoC [USD million]*	*GDP [USD million]*	*%CoC [of GDP]*
Agriculture & Allied Activities	***12,496.0***	***203,934.0***	***6.1%***
A. Agriculture, Forestry & Fishing			
Industry	***22,805.0***	***488,110.0***	***4.7%***
B. Mining & Quarrying	1,619.0	26,388.0	6.1%
Petroleum & Natural Gas	172.0	11,677.0	1.5%
Other Mining	417.0	14,711.0	2.8%
C. Manufacturing	10,277.0	178,757.0	5.7%
Non-metallic products	50.0	10,310.0	0.5%
Metal products & Basic Metal Industries	1,472.0	41,200.0	3.6%
Electrical machinery	135.0	9,254.0	1.5%
Transport equipment	374.0	17,313.0	2.2%
Chemicals, etc.	486.0	22,489.0	2.2%
Petroleum Refining and other related products	304.0	18,425.0	1.6%
Paper & Printing, etc.	112.0	6,209.0	1.8%
Food products, Beverages & Tobacco	69.0	18,788.0	0.4%
Other manufacturing (General)	7,275.0	34,769.0	20.9%
F. Construction	8,015.0	251,266.0	3.2%
New Construction	6,472.0	201,635.0	3.2%
Repair & Maintenance	1,543.0	49,631.0	3.1%
D. Electricity, Gas, Steam, & AC Supply	2,102.0	18,445.0	11.4%
Gas (icl. distribution pipelines)	11.00	1,367.0	0.8%
Electricity, Power Generation, Transmission	1,721.0	17,078.0	10.1%
E. Water Supply, Sewage, Waste Management & Remediation	792.0	13,254.0	6.0%
Services	***13,471.0***	***396,093.0***	**3.4%**
I. Accommodation & Food Service Activities	3,655.0	15,823.0	23.1%
H. Transportation & Storage	2,392.0	80,267.0	3.0%
Rail transport, Trains	496.0	17,608.0	2.8%
Road transport, Automobiles	1,614.0	52,073.0	3.1%
Water transport, Ships, Marine	83.0	2,347.0	3.5%
Air transport	104.0	2,945.0	3.5%
Transmission Pipelines			
Power Transmission			
Waterways & Ports			
Hazardous Material Transport			
Transportation Services	72.00	4,532.00	1.6%
Highway Bridges			
Storage	23.00	762.0	3.0%
J. Information & Communication	799.0	21,125.0	3.8%
K. Financial & Insurance Activities	1,194.0	53,061.0	2.3%
Real Estate	1,153.00	49,707.0	2.3%
Legal Services	41.00	3,354.0	1.2%
G. Wholesale and retail trade	3,660.0	173,464.0	2.1%
R. Arts, Entertainment & Recreation	16.00	4,872.0	0.3%
M. Professional, Scientific & Technical Activities			
S. Other Service Activities	1,590.0		
Community, Social & Personal Services	165.0	47,481.0	0.3%
N. Administrative & Support Services Activities			
O. Public Administration & Defense; Social Security			
P. Education	98.0	32,578.0	0.3%
Q. Human Health & Social Work Activities	67.0	14,903.0	0.4%

Table A-4. Cost of Corrosion by Sector for United States 1998 study

Sector	*CoC [USD billion]*	*GDP [USD billion]*	*%CoC [of GDP]*
Agriculture & Allied Activities	***1.1***	***96.6***	***1.1%***
A. Agriculture, Forestry & Fishing			
Industry	***159.7***	***1,712.4***	***9.3%***

B. Mining & Quarrying	1.5	100.2	1.5%
Petroleum & Natural Gas	1.4	72.8	1.9%
Other Mining	0.1	27.4	0.4%
C. Manufacturing	60.3	2,092.4	2.9%
Non-metallic products			
Metal products & Basic Metal Industries			
Electrical machinery			
Transport equipment			
Chemicals, etc.	1.35	164.8	0.8%
Petroleum Refining and other related products	3.7	89.7	4.1%
Paper & Printing, etc.	6.0	151.3	4.0%
Food products, Beverages & Tobacco	2.1	139.1	1.5%
Other manufacturing (General)	47.15	1,547.5	3.0%
F. Construction	50.0	380.8	13.1%
New Construction			
Repair & Maintenance			
D. Electricity, Gas, Steam, & AC Supply	11.9	204.8	5.8%
Gas (icl. distribution pipelines)	5.0		
Electricity, Power Generation, Transmission	6.9		
E. Water Supply, Sewage, Waste Management & Remediation	36.0		
Services	**93.5**	**6,972.5**	**1.3%**
I. Accommodation & Food Service Activities			
H. Transportation & Storage	56.5	539.6	10.5%
Rail transport, Trains	0.5	24.3	2.1%
Road transport, Automobiles	23.4	323.4	7.2%
Water transport, Ships, Marine	2.7	13.6	19.9%
Air transport	2.2	85.8	2.6%
Transmission Pipelines	7.0	6.1	114.8%
Power Transmission	0.6		
Waterways & Ports	0.3		
Hazardous Material Transport	0.9		
Transportation Services	3.47	86.40	4.0%
Highway Bridges	8.30		
Storage	7.1		
J. Information & Communication	31.2	238.5	13.1%
K. Financial & Insurance Activities			
Real Estate			
Legal Services			
G. Wholesale and retail trade			
R. Arts, Entertainment & Recreation	5.8	99.2	5.8%
M. Professional, Scientific & Technical Activities			
S. Other Service Activities			
Community, Social & Personal Services	5.8	2,933.2	0.2%
N. Administrative & Support Services Activities			
O. Public Administration & Defense; Social Security			
P. Education			
Q. Human Health & Social Work Activities			

Table A-5. Cost of Corrosion by Sector for Japan 1997 study

Sector	*CoC [Yen billion]*	*GDP [Yen billion]*	*%CoC [of GDP]*
Agriculture & Allied Activities		**6,172**	
A. Agriculture, Forestry & Fishing			
Industry	***4713.5***	***131,672***	***3.58%***
B. Mining & Quarrying			
Petroleum & Natural Gas			
Other Mining			
C. Manufacturing	2659.1		
Non-metallic products			
Metal products & Basic Metal Industries	27.6		
Electrical machinery			
Transport equipment			
Chemicals, etc.	1070		
Petroleum Refining and other related products			
Paper & Printing, etc.			
Food products, Beverages & Tobacco			
Other manufacturing (General)	1561.5		
F. Construction	1597.6		
New Construction			
Repair & Maintenance			
D. Electricity, Gas, Steam, & AC Supply	456.8		
Gas (icl. distribution pipelines)			
Electricity, Power Generation, Transmission			
E. Water Supply, Sewage, Waste Management & Remediation			
Services	**544.7**	**376,499**	**0.14%**
I. Accommodation & Food Service Activities			
H. Transportation & Storage	544.7		
Rail transport, Trains	18.4		
Road transport, Automobiles	445.7		
Water transport, Ships, Marine	80.6		
Air transport			
Transmission Pipelines			
Power Transmission			
Waterways & Ports			
Hazardous Material Transport			
Transportation Services			
Highway Bridges			
Storage			
J. Information & Communication			
K. Financial & Insurance Activities			
Real Estate			
Legal Services			
G. Wholesale and retail trade			
R. Arts, Entertainment & Recreation			
M. Professional, Scientific & Technical Activities			
S. Other Service Activities			
Community, Social & Personal Services			
N. Administrative & Support Services Activities			
O. Public Administration & Defense; Social Security			
P. Education			
Q. Human Health & Social Work Activities			

Table A-6. Cost of Corrosion by Sector for Kuwait 1987 study

Sector	*CoC [KD thousand]*	*GDP [KD thousand]*	*%CoC [of GDP]*
Agriculture & Allied Activities	**1,761**	**18,517**	***9.5%***
A. Agriculture, Forestry & Fishing	1,761		
Industry	***69,789***	**3,123,194**	***2.23%***
B. Mining & Quarrying	8,786		
Petroleum & Natural Gas			
Other Mining			
C. Manufacturing	32,734		
Non-metallic products	8,292		
Metal products & Basic Metal Industries	673		
Electrical machinery			
Transport equipment			
Chemicals, etc.	3,252		
Petroleum Refining and other related products	10,480		
Paper & Printing, etc.			
Food products, Beverages & Tobacco	3,585		
Other manufacturing (General)	6,452		
F. Construction	34,394		
New Construction			
Repair & Maintenance			
D. Electricity, Gas, Steam, & AC Supply	-6,125		
Gas (icl. distribution pipelines)			
Electricity, Power Generation, Transmission			
E. Water Supply, Sewage, Waste Management & Remediation			
Services	**250,028**	**3,030,610**	**8.3%**
I. Accommodation & Food Service Activities	7,258		
H. Transportation & Storage	17,627		
Rail transport, Trains			
Road transport, Automobiles			
Water transport, Ships, Marine			
Air transport			
Transmission Pipelines			
Power Transmission			
Waterways & Ports			
Hazardous Material Transport			
Transportation Services			
Highway Bridges			
Storage			
J. Information & Communication			
K. Financial & Insurance Activities			
Real Estate			
Legal Services			
G. Wholesale and retail trade			
R. Arts, Entertainment & Recreation			
M. Professional, Scientific & Technical Activities			
S. Other Service Activities	118,203		
Community, Social & Personal Services	106,940		
N. Administrative & Support Services Activities			
O. Public Administration & Defense; Social Security			
P. Education			
Q. Human Health & Social Work Activities			

Table A-7. Cost of Corrosion by Sector for United Kingdom 1970 study

Sector	*CoC [£ million]*	*GDP [£ million]*	*%CoC [of GDP]*
Agriculture & Allied Activities		***273.0***	
A. Agriculture, Forestry & Fishing			
Industry	***680***	***7950.0***	***8.55%***
B. Mining & Quarrying			
Petroleum & Natural Gas			
Other Mining			
C. Manufacturing	***345***		
Non-metallic products			
Metal products & Basic Metal Industries	15		
Electrical machinery			
Transport equipment			
Chemicals, etc.			
Petroleum Refining and other related products	180		
Paper & Printing, etc.			
Food products, Beverages & Tobacco	40		
Other manufacturing (General)	110		
F. Construction	250		
New Construction	250		
Repair & Maintenance			
D. Electricity, Gas, Steam, & AC Supply	60		
Gas (icl. distribution pipelines)			
Electricity, Power Generation, Transmission	60		
E. Water Supply, Sewage, Waste Management & Remediation	25		
Services	**630**	**30771.0**	**2.05%**
I. Accommodation & Food Service Activities			
H. Transportation & Storage	630		
Rail transport, Trains			
Road transport, Automobiles	350		
Water transport, Ships, Marine	280		
Air transport			
Transmission Pipelines			
Power Transmission			
Waterways & Ports			
Hazardous Material Transport			
Transportation Services			
Highway Bridges			
Storage			
J. Information & Communication			
K. Financial & Insurance Activities			
Real Estate			
Legal Services			
G. Wholesale and retail trade			
R. Arts, Entertainment & Recreation			
M. Professional, Scientific & Technical Activities			
S. Other Service Activities			
Community, Social & Personal Services			
N. Administrative & Support Services Activities			
O. Public Administration & Defense; Social Security	55		
P. Education			
Q. Human Health & Social Work Activities			

India 2011-2012 and United States 1998 studies provided the most significant Sector detail. There are two main points pertinent to the IMPACT cost of corrosion analysis: (i) the degree of Sector detail varies significantly from study to study and (ii) there are only five studies with Sector data that can be applied to a global CoC analysis that uses Sector detail as a basis.

A.6.3 Economic Sector Analysis

The economic sector analysis divides each economy by GDP in Agriculture, Industry and Services based on 2013 data (primarily 2013 but varies slightly by country).[23] The economic breakdown for the five countries used in this analysis is shown in Figure A-1. The United States, United Kingdom and Japan are very similar, with India and Kuwait more unique.

In order to address the economic sectors for different parts of the world, the global economy was divided into economic regions with similar economies. Figure A-2 shows a division of the world economy into regions, in accordance with the 2013 GDP. Figure A-3 shows the Sector division for each economic Region.

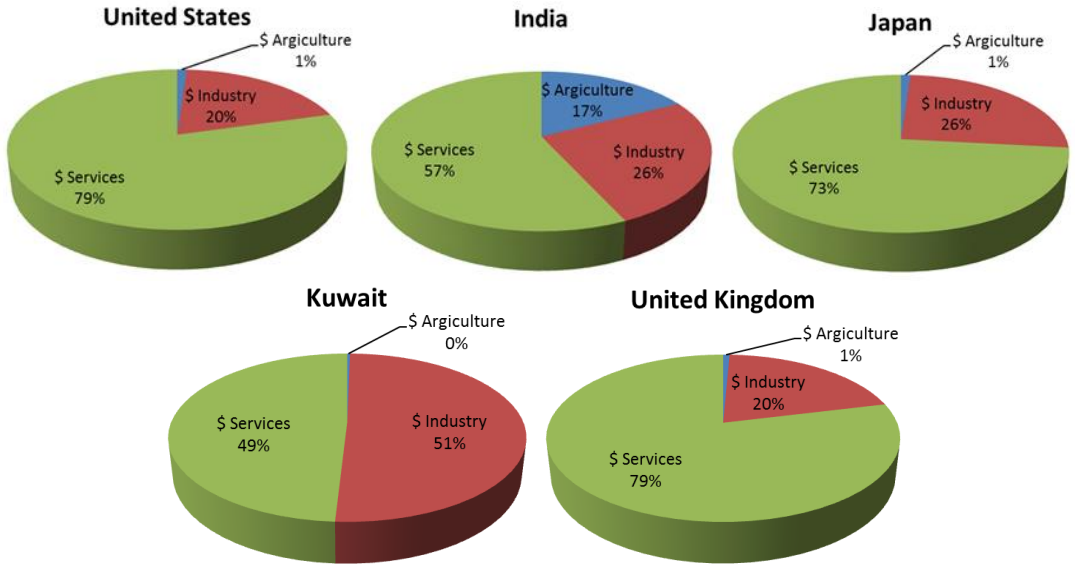

Figure A-1. Economic Sectors for the five countries used in the Global Cost of Corrosion Study

[23] The World Fact book

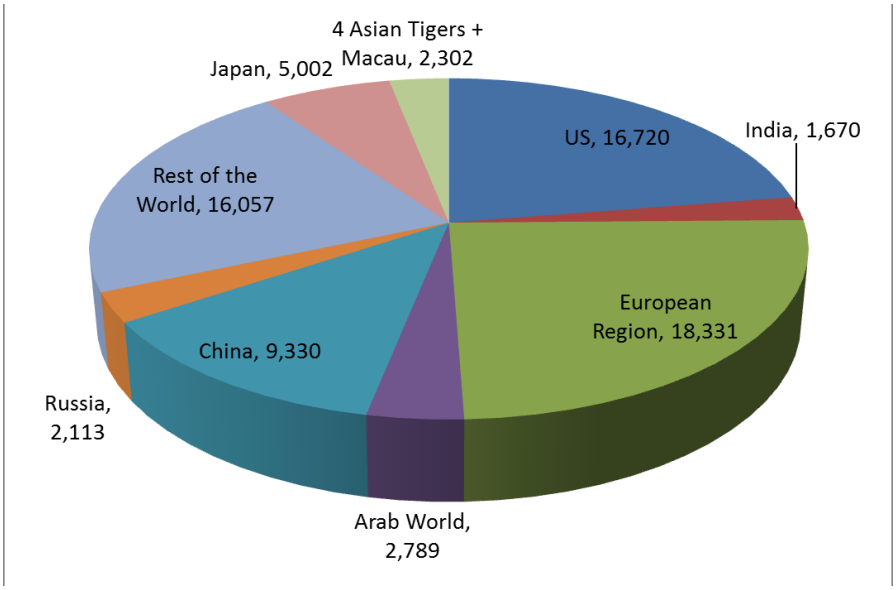

Figure A-2. Global GDP by Economic Region (BUSD)

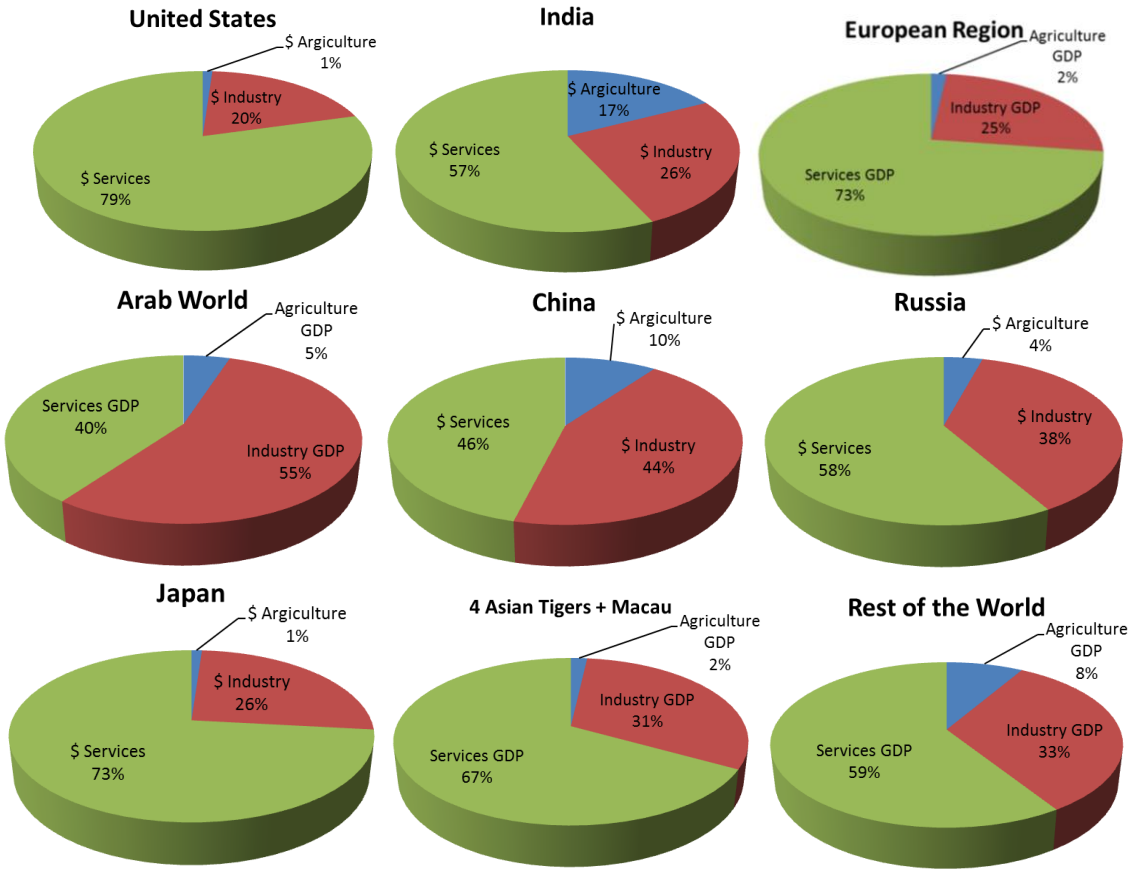

Figure A-3. Economic sectors for the nine economic Regions in Figure A-2

A.6.4 Global Cost of Corrosion Analysis

The global Cost of Corrosion was assessed by mapping the Cost of Corrosion studies to the nine economic Regions using Table A-8. The European Region, Arab World, Four Asian Tigers + Macau include the following countries:

- European Region

  - Austria
  - Belgium
  - Bulgaria
  - Croatia
  - Cyprus
  - Czech Republic
  - Denmark
  - Estonia
  - Finland
  - France
  - Germany
  - Greece
  - Hungary
  - Ireland
  - Italy
  - Latvia
  - Lithuania
  - Luxembourg
  - Malta
  - Netherlands
  - Norway
  - Poland
  - Portugal
  - Romania
  - Slovakia
  - Slovenia
  - Spain
  - Sweden
  - Switzerland
  - United Kingdom

- Arab World

  - Algeria
  - Bahrain
  - Comoros
  - Djibouti
  - Egypt
  - Iraq
  - Jordan
  - Kuwait
  - Lebanon
  - Libya
  - Mauritania
  - Morocco
  - Oman
  - Qatar
  - Saudi Arabia
  - Somalia
  - Sudan
  - Syria
  - Tunisia
  - UAE
  - West Bank
  - Yemen

- Four Asian Tigers + Macau

  - Hong Kong
  - Korea, South
  - Macau
  - Singapore
  - Taiwan

Table A-8. Map of Cost of Corrosion studies to economic Regions

Economic Regions	CoC Study used for Region CoC	Agriculture %CoC	Industry %CoC	Services %CoC
United States	United States 1998	1.1	9.3	1.3
India	India 2011	6.1	4.7	3.4
European Region	United Kingdom 1970	1.1*	8.6	2.2
Arab World	Kuwait 1987	9.5	2.2	8.3
China	India 2011	6.1	4.7	3.4
Russia	India 2011	6.1	4.7	3.4
Japan	Japan 1997	1.1*	3.6	0.1
Four Asian Tigers + Macau	Average of India and Japan studies	1.1*	3.6	0.1
Rest of the World	Average of all studies	3.8	7.4	1.2

Note: * CoC was not reported in primary study but value for the United States 1998 Study was used.

The World Factbook provides a breakdown of each country's GDP into the economic sectors; Agriculture, Industry and Services. The data by country is provided in Table A-10 at the end of this Appendix. Using Table A-8 and Table A-9, the Cost of Corrosion for each country by Sector and the total Cost of Corrosion for each country was determined. The Global Cost of Corrosion is then determined for each economic Region by Sector and is given in Table A-9. The global cost of corrosion is estimated to be 2,505 billion USD or 3.4 percent of the global GDP (2013).

Table A-9. Global Cost of Corrosion by Region by Sector (Billion USD)

Economic Regions	Agriculture CoC USD billion	Industry CoC USD billion	Services CoC USD billion	Total CoC USD billion	Total GDP USD billion	CoC % GDP
United States	2.0	303.2	146.0	451.3	16,720	2.7%
India	17.7	20.3	32.3	70.3	1,670	4.2%
European Region	3.5	401	297	701.5	18,331	3.8%
Arab World	13.3	34.2	92.6	140.1	2,789	5.0%
China	56.2	192.5	146.2	394.9	9,330	4.2%
Russia	5.4	37.2	41.9	84.5	2,113	4.0%
Japan	0.6	45.9	5.1	51.6	5,002	1.0%
Four Asian Tigers + Macau	1.5	29.9	27.3	58.6	2,302	2.5%
Rest of the World	52.4	382.5	117.6	552.5	16,057	3.4%
Global	**152.7**	**1446.7**	**906.0**	**2505.4**	**74,314**	**3.4%**

This estimate of USD2,505 billion is based on available studies that had sufficient sector detail for a global sector analysis to be performed. As additional studies become available, the global cost of corrosion could be updated and improved. Previous cost of corrosion studies indicated that between 15 and 35 percent of the cost of corrosion could be saved by using current available corrosion control practices, which is between USD375 and USD875 billion globally.

Table A-10. GDP Sector Breakdown by Country

Country	GDP (Official Exchange Rate) (USD billion)	% Agriculture	$ Agriculture	% Industry	$ Industry	% Services	$ Services	Year Est.
Afghanistan	$20.65	20.0%	4.13	25.6%	5.29	54.4%	11.23	2011
Albania	$12.80	19.5%	2.50	12.0%	1.54	68.5%	8.77	2011
Algeria	$215.70	9.4%	20.28	62.6%	135.03	28.0%	60.40	2011
American Samoa	$0.46	N/A		N/A		N/A		
Andorra	$4.80	14.0%	0.67	79.0%	3.79	6.0%	0.29	2011
Angola	$124.00	10.2%	12.65	61.4%	76.14	28.4%	35.22	2011
Anguilla	$0.18	2.5%	0.00	23.6%	0.04	73.8%	0.13	2013
Antigua and Barbuda	$1.22	2.2%	0.03	16.4%	0.20	81.4%	0.99	2013
Argentina	$484.60	9.3%	45.07	29.7%	143.93	61.0%	295.61	2013
Armenia	$10.44	20.6%	2.15	37.3%	3.89	42.1%	4.40	2013
Aruba	$2.52	0.4%	0.01	33.3%	0.84	66.3%	1.67	2002
Australia	$1,488.00	3.8%	56.54	27.4%	407.71	68.7%	1,022.26	2013
Austria	$417.90	1.6%	6.69	28.6%	119.52	69.8%	291.69	2013
Azerbaijan	$76.01	6.2%	4.71	63.0%	47.89	69.8%	53.05	2013
Bahamas, The	$8.37	2.1%	0.18	7.1%	0.59	90.8%	7.60	2013
Bahrain	$28.36	0.3%	0.09	46.7%	13.24	53.0%	15.03	2013
Bangladesh	$140.20	17.2%	24.11	28.9%	40.52	53.9%	75.57	2013
Barbados	$4.26	3.1%	0.13	13.9%	0.59	83.0%	3.54	2013
Belarus	$69.24	9.2%	6.37	46.2%	31.99	44.7%	30.95	2013
Belgium	$507.40	0.8%	4.06	22.6%	114.67	76.6%	388.67	2013
Belize	$1.64	13.0%	0.21	23.0%	0.38	64.0%	1.05	2012
Benin	$8.36	31.6%	2.64	12.9%	1.08	55.6%	4.65	2013
Bermuda	$5.60	0.7%	0.04	5.7%	0.32	93.5%	5.24	2013
Bhutan	$2.13	13.8%	0.29	41.2%	0.88	45.0%	0.96	2013
Bolivia	$30.79	9.2%	2.83	38.5%	11.85	52.3%	16.10	2013
Bosnia and Herzegovina	$18.87	8.1%	1.53	26.4%	4.98	65.5%	12.36	2013
Botswana	$15.53	1.9%	0.30	35.7%	5.54	62.4%	9.69	2013
Brazil	$2,190	5.5%	120.45	26.4%	578.16	68.1%	1,491.39	2013
British Virgin Islands	$1.10	1.1%	0.01	11.7%	0.13	87.2%	0.95	2013
Brunei	$16.56	0.7%	0.12	70.9%	11.74	28.4%	4.70	2013
Bulgaria	$53.70	6.7%	3.60	30.3%	16.27	63.0%	33.83	2013
Burkina Faso	$12.13	33.6%	4.08	23.6%	2.86	42.8%	5.19	2013
Burma	$59.43	38.0%	22.58	20.3%	12.06	41.7%	24.78	2013
Burundi	$2.68	34.4%	0.92	18.4%	0.49	47.2%	1.26	2013
Cabo Verde	$1.96	9.3%	0.18	18.8%	0.37	71.9%	1.41	2013
Cambodia	$15.64	34.8%	5.44	24.5%	3.83	40.7%	6.37	2013
Cameroon	$27.88	20.6%	5.74	27.3%	7.61	52.1%	14.53	2013
Canada	$1,825.00	1.7%	31.03	28.4%	518.30	69.9%	1,275.68	2013
Cayman Islands	$2.25	0.3%	0.01	27.4%	0.62	72.3%	1.63	2013
Central African Republic	$2.05	56.6%	1.16	14.5%	0.30	28.9%	0.59	2013
Chad	$13.59	46.3%	6.29	9.9%	1.35	43.8%	5.95	2013
Chile	$281.70	3.6%	10.14	35.4%	99.72	61.0%	171.84	2013
China	$9,330.00	10.0%	933.00	43.9%	4,095.87	46.1%	4,301.13	2013
Columbia	$369.20	6.6%	24.37	37.8%	139.56	55.6%	205.28	2013
Comoros	$0.66	51.0%	0.34	10.0%	0.07	39.0%	0.26	2012
Congo, Democratic Republic of the	$18.56	44.3%	8.22	21.7%	4.03	34.0%	6.31	2013
Congo, Republic of the	$14.25	3.3%	0.47	73.9%	10.53	22.9%	3.26	2013
Cook Islands	$0.18	5.1%	0.01	12.7%	0.02	82.1%	0.15	2010
Costa Rica	$48.51	6.2%	3.01	21.3%	10.33	72.5%	35.17	2013
Cote d'Ivoire	$28.28	26.3%	7.44	21.3%	6.02	52.4%	14.82	2013
Croatia	$59.14	5.0%	2.96	25.8%	15.26	69.2%	40.92	2013
Cuba	$72.30	3.8%	2.75	22.3%	16.12	73.9%	53.43	2013
Curacao	$5.60	0.7%	0.04	15.5%	0.87	83.8%	4.69	2012
Cyprus	$21.78	2.4%	0.52	15.9%	3.46	81.7%	17.79	2013
Czech Republic	$194.80	2.4%	4.68	37.3%	72.66	60.3%	117.46	2012
Denmark	$324.30	1.5%	4.86	21.7%	70.37	76.8%	249.06	2013

Table A-10. GDP Sector Breakdown by Country

Country	GDP (Official Exchange Rate) (USD billion)	% Agriculture	$ Agriculture	% Industry	$ Industry	% Services	$ Services	Year Est.
Djibouti	$1.46	3.0%	0.04	17.3%	0.25	79.7%	1.16	2013
Dominica	$0.50	15.7%	0.08	15.6%	0.08	68.7%	0.34	2013
Dominican Republic	$59.27	6.0%	3.56	29.1%	17.25	64.9%	38.47	2013
Ecuador	$91.41	5.9%	5.39	35.1%	32.08	59.0%	53.93	2013
Egypt	$262.00	14.5%	37.99	37.5%	98.25	48.0%	125.76	2013
El Salvador	$24.67	10.3%	2.54	29.5%	7.28	60.1%	14.83	2013
Equatorial Guinea	$17.08	4.6%	0.79	87.3%	14.91	8.1%	1.38	2013
Eritrea	$3.44	11.7%	0.40	26.9%	0.92	61.4%	2.11	2013
Estonia	$24.28	3.9%	0.95	30.0%	7.28	66.2%	16.07	2013
Ethiopia	$47.34	47.0%	22.25	10.8%	5.11	42.2%	19.98	2013
European Union	$16,950.00	1.8%	305.10	25.2%	4,271.40	72.8%	12,339.60	2013
Falkland Islands	$0.16	95.0%	0.16	N/A		N/A		1996
Faroe Islands	$2.32	16.0%	0.37	29.0%	0.67	55.0%	1.28	2007
Fiji	$4.22	11.7%	0.49	18.1%	0.76	70.2%	2.96	2013
Finland	$259.60	2.9%	7.53	25.1%	65.16	71.9%	186.65	2013
France	$2,739.00	1.9%	52.04	18.7%	512.19	79.4%	2,174.77	2013
French Polynesia	$5.65	3.1%	0.18	20.0%	1.13	76.9%	4.34	2006
Gabon	$19.97	3.6%	0.72	63.9%	12.76	32.5%	6.49	2013
Gambia, The	$0.90	19.7%	0.18	12.6%	0.11	67.7%	0.61	2013
Georgia	$15.95	8.5%	1.36	21.6%	3.45	69.9%	11.15	2013
Germany	$3,593.00	0.8%	28.74	30.1%	1,081.49	69.0%	2,479.17	2013
Ghana	$45.55	21.5%	9.79	28.7%	13.07	49.8%	22.68	2013
Gibraltar	$1.11	0.0%	0.00	0.0%	0.00	100.0%	1.11	2008
Greece	$243.30	3.5%	8.52	16.0%	38.93	80.5%	195.86	2013
Greenland	$2.16	4.0%	0.09	29.0%	0.63	67.0%	1.45	2009
Grenada	$0.81	5.6%	0.05	15.8%	0.13	78.5%	0.64	2013
Guam	$4.60	N/A		N/A		N/A		2010
Guatemala	$53.90	13.5%	7.28	23.8%	12.83	62.7%	33.80	2013
Guernsey	$2.74	3.0%	0.08	10.0%	0.27	87.0%	2.39	2000
Guinea	$6.54	22.9%	1.50	46.5%	3.04	30.5%	2.00	2013
Guinea-Bissau	$0.88	58.0%	0.51	13.5%	0.12	28.5%	0.25	2013
Guyana	$3.02	20.7%	0.63	38.5%	1.16	40.8%	1.23	2013
Haiti	$8.29	24.1%	2.00	19.9%	1.65	56.0%	4.64	2013
Honduras	$18.88	14.0%	2.64	28.2%	5.32	57.8%	10.91	2013
Hong Kong	$272.10	0.0%	0.00	6.9%	18.77	93.0%	253.05	2013
Hungary	$130.60	3.4%	4.44	28.0%	36.57	68.7%	89.72	2013
Iceland	$14.59	5.9%	0.86	22.9%	3.34	71.2%	10.39	2013
India	$1,670.00	17.4%	290.58	25.8%	430.86	56.9%	950.23	2013
Indonesia	$867.50	14.3%	124.05	46.6%	404.26	39.1%	339.19	2013
Iran	$411.90	10.6%	43.66	44.9%	184.94	44.5%	183.30	2013
Iraq	$221.80	3.3%	7.32	64.6%	143.28	32.1%	71.20	2013
Ireland	$220.90	1.6%	3.53	28.0%	61.85	70.4%	155.51	2013
Isle of Man	$4.08	1.0%	0.04	11.0%	0.45	88.0%	3.59	2009
Israel	$272.70	2.4%	6.54	31.2%	85.08	66.4%	181.07	2013
Italy	$2,068.00	2.0%	41.36	24.4%	504.59	73.5%	1,519.98	2013
Jamaica	$14.39	6.5%	0.94	29.4%	4.23	64.1%	9.22	2013
Japan	$5,007.00	1.1%	55.08	25.6%	1,281.79	73.2%	3,665.12	2013
Jersey	$5.10	2.0%	0.10	2.0%	0.10	96.0%	4.90	2010
Jordan	$34.08	3.2%	1.09	29.9%	10.19	67.0%	22.83	2013
Kazakhstan	$224.90	5.2%	11.69	37.9%	85.24	56.9%	127.97	2011
Kenya	$45.31	29.3%	13.28	17.4%	7.88	53.3%	24.15	2013
Kiribati	$0.17	24.3%	0.04	7.9%	0.01	67.8%	0.12	2010
Korea, North	$28.00	23.4%	6.55	47.2%	13.22	29.4%	8.23	2012
Korea, South	$1,198.00	2.6%	31.15	39.2%	469.62	58.2%	697.24	2013
Kosovo	$7.15	12.9%	0.92	22.6%	1.62	64.5%	4.61	2009
Kuwait	$179.50	0.3%	0.54	50.6%	90.83	49.1%	88.13	2013
Kyrgyzstan	$7.23	20.6%	1.49	34.4%	2.49	44.8%	3.24	2013

Table A-10. GDP Sector Breakdown by Country

Country	GDP (Official Exchange Rate) (USD billion)	% Agriculture	$ Agriculture	% Industry	$ Industry	% Services	$ Services	Year Est.
Laos	$10.10	24.8%	2.50	32.0%	3.23	37.5%	3.79	2013
Latvia	$30.38	4.9%	1.49	25.7%	7.81	69.4%	21.08	2013
Lebanon	$43.49	4.6%	2.00	20.0%	8.70	75.4%	32.79	2013
Lesotho	$2.46	7.4%	0.18	34.5%	0.85	58.2%	1.43	2013
Liberia	$1.98	76.9%	1.52	5.4%	0.11	17.7%	0.35	2002
Libya	$70.92	2.0%	1.42	58.3%	41.35	39.7%	28.16	2013
Liechtenstein	$5.11	8.0%	0.41	37.0%	1.89	55.0%	2.81	2009
Lithuania	$46.71	3.7%	1.73	28.3%	13.22	68.0%	31.76	2013
Luxembourg	$60.54	0.3%	0.18	13.3%	8.05	86.4%	52.31	2013
Macau	$51.68	0.0%	0.00	6.5%	3.36	93.5%	48.32	2013
Macedonia	$10.65	10.2%	1.09	27.5%	2.93	62.3%	6.63	2013
Madagascar	$10.53	27.3%	2.87	16.4%	1.73	56.3%	5.93	2013
Malawi	$3.68	29.4%	1.08	18.9%	0.70	51.7%	1.90	2013
Malaysia	$312.40	11.2%	34.99	40.6%	126.83	48.1%	150.26	2013
Maldives	$2.27	3.0%	0.07	17.0%	0.39	80.0%	1.82	2012
Mali	$11.37	38.5%	4.38	24.4%	2.77	37.0%	4.21	2013
Malta	$9.54	1.4%	0.13	25.3%	2.41	73.3%	6.99	2013
Marshall Islands	$0.19	14.3%	0.03	13.9%	0.03	71.8%	0.14	2011
Mauritania	$4.18	16.9%	0.71	54.6%	2.28	28.5%	1.19	2013
Mauritius	$11.90	4.5%	0.54	22.0%	2.62	73.4%	8.73	2013
Mexico	$1,327.00	3.6%	47.77	36.6%	485.68	59.8%	793.55	2013
Micronesia, Federated States of	$0.34	14.0%	0.05	12.0%	0.04	74.0%	0.25	2011
Moldova	$7.93	13.8%	1.09	19.9%	1.58	66.2%	5.25	2013
Monaco	$5.75	0.0%	0.00	10.0%	0.57	90.0%	5.17	2011
Mongolia	$11.14	16.5%	1.84	32.6%	3.63	50.9%	5.67	2013
Montenegro	$4.52	0.8%	0.04	11.3%	0.51	87.9%	3.97	2011
Montserrat		1.6%		23.2%		75.1%		2013
Morocco	$104.80	15.1%	15.82	31.7%	33.22	53.2%	55.75	2012
Mozambique	$14.67	28.7%	4.21	24.9%	3.65	46.4%	6.81	2013
Namibia	$12.30	7.7%	0.95	29.6%	3.64	62.6%	7.70	2013
Nauru		6.1%		33.0%		60.8%		2009
Nepal	$19.34	36.8%	7.12	14.5%	2.80	48.7%	9.42	2013
Netherlands	$722.30	2.6%	18.78	25.4%	183.46	72.1%	520.78	2013
New Caledonia	$9.28	2.1%	0.19	30.0%	2.78	67.9%	6.30	2013
New Zealand	$181.10	5.0%	9.06	25.5%	46.18	69.5%	125.86	2013
Nicaragua	$11.26	17.1%	1.93	25.5%	2.87	57.5%	6.47	2013
Niger	$7.30	35.2%	2.57	14.2%	1.04	50.6%	3.70	2013
Nigeria	$502.00	30.9%	155.12	43.0%	215.86	26.0%	130.52	2012
Niue	$0.01	23.5%	0.00	26.9%	0.00	49.5%	0.00	2009
Northern Mariana Islands	$0.73	1.7%	0.01	3.3%	0.02	95.0%	0.70	2010
Norway	$515.80	1.2%	6.19	42.3%	218.18	56.5%	291.43	2013
Oman	$81.95	1.0%	0.82	64.4%	52.78	34.6%	28.35	2013
Pakistan	$236.50	25.3%	59.83	21.6%	51.08	53.1%	125.58	2013
Palau	$0.22	3.2%	0.01	20.0%	0.04	76.8%	0.17	2012
Panama	$40.62	3.7%	1.50	17.9%	7.27	78.4%	31.85	2013
Papua New Guinea	$16.10	27.6%	4.44	39.1%	6.30	33.3%	5.36	2013
Paraguay	$30.56	20.4%	6.23	17.7%	5.41	61.9%	18.92	2013
Peru	$210.30	6.2%	13.04	37.5%	78.86	56.3%	118.40	2013
Philippines	$272.20	11.2%	30.49	31.6%	86.02	57.2%	155.70	2013
Poland	$513.90	4.0%	20.56	33.3%	171.13	62.7%	322.22	2013
Portugal	$219.30	2.6%	5.70	22.2%	48.68	75.2%	164.91	2013
Puerto Rico	$93.52	0.7%	0.65	48.8%	45.64	50.5%	47.23	2013
Qatar	$213.10	0.1%	0.21	72.2%	153.86	27.7%	59.03	2013
Romania	$188.90	6.4%	12.09	34.2%	64.60	59.4%	112.21	2013
Russia	$2,113.00	4.2%	88.75	37.5%	792.38	58.3%	1,231.88	2013

Table A-10. GDP Sector Breakdown by Country

Country	GDP (Official Exchange Rate) (USD billion)	% Agriculture	$ Agriculture	% Industry	$ Industry	% Services	$ Services	Year Est.
Rwanda	$7.70	31.9%	2.46	14.8%	1.14	53.3%	4.10	2013
Saint Helena, Ascension, and Tristan da Cunha	N/A							
Saint Kitts and Nevis	$0.77	1.8%	0.01	23.1%	0.18	75.1%	0.58	2013
Saint Lucia	$1.38	3.1%	0.04	17.4%	0.24	79.5%	1.09	2013
Saint Martin	$0.56	1.0%	0.01	15.0%	0.08	84.0%	0.47	2000
Saint Pierre and Miguelon	$0.22	2.0%	0.00	15.0%	0.03	83.0%	0.18	2006
Saint Vincent and the Grenadines	$0.74	5.4%	0.04	20.3%	0.15	74.4%	0.55	2013
Samoa	$0.71	10.2%	0.07	25.9%	0.18	64.0%	0.45	2013
San Marino	$1.87	0.1%	0.00	39.2%	0.73	60.7%	1.13	2009
Sao Tome and Principe	$0.31	13.7%	0.04	19.5%	0.06	66.8%	0.21	2013
Saudi Arabia	$718.50	2.0%	14.37	62.5%	449.06	35.5%	255.07	2013
Senegal	$15.36	14.9%	2.29	22.7%	3.49	62.4%	9.58	2013
Serbia	$43.68	7.9%	3.45	31.8%	13.89	60.3%	26.34	2013
Seychelles	$1.27	2.0%	0.03	18.7%	0.24	79.4%	1.01	2013
Sierra Leone	$4.61	47.9%	2.21	18.6%	0.86	33.5%	1.54	2013
Singapore	$295.70	0.0%	0.00	29.4%	86.94	70.6%	208.76	2013
Saint Maarten	$0.79	0.4%	0.00	18.3%	0.15	81.3%	0.65	2008
Slovakia	$96.96	3.1%	3.01	30.8%	29.86	47.0%	45.57	2013
Slovenia	$46.82	2.8%	1.31	28.9%	13.53	68.3%	31.98	2013
Solomon Islands	$1.10	50.0%	0.55	10.6%	0.12	39.4%	0.43	2013
Somalia	$2.37	59.3%	1.41	7.2%	0.17	33.5%	0.79	2012
South Africa	$353.90	2.6%	9.20	29.0%	102.63	68.4%	242.07	2013
South Sudan	$11.77	N/A		N/A		N/A		
Spain	$1,356.00	3.1%	42.04	26.0%	352.56	70.8%	960.05	2013
Sri Lanka	$65.12	10.6%	6.90	32.4%	21.10	57.0%	37.12	2013
Sudan	$52.50	27.4%	14.39	33.6%	17.64	39.0%	20.48	2013
Suriname	$5.01	8.9%	0.45	36.6%	1.83	54.5%	2.73	2013
Swaziland	$3.81	7.6%	0.29	47.8%	1.82	44.6%	1.70	2013
Sweden	$552.00	2.0%	11.04	31.3%	172.78	66.8%	368.74	2013
Switzerland	$646.20	0.7%	4.52	26.8%	173.18	72.5%	468.50	2013
Syria	$64.70	17.6%	11.39	22.2%	14.36	60.2%	38.95	2013
Taiwan	$484.70	2.0%	9.69	29.4%	142.50	68.6%	332.50	2013
Tajikistan	$8.51	21.1%	1.80	23.2%	1.98	55.7%	4.74	2013
Tanzania	$31.94	27.6%	8.82	25.0%	7.99	47.4%	15.14	2013
Thailand	$400.90	12.1%	48.51	46.6%	186.82	44.2%	177.20	2013
Timor-Leste	$6.13	2.6%	0.16	81.6%	5.00	15.8%	0.97	2013
Togo	$4.30	27.6%	1.19	33.7%	1.45	38.7%	1.66	2013
Tokelau	N/A							
Tonga	$0.48	20.9%	0.10	21.9%	0.10	57.2%	0.27	2013
Trinidad and Tobago	$27.13	0.3%	0.08	57.7%	15.65	42.0%	11.39	2013
Tunisia	$48.38	8.6%	4.16	30.4%	14.71	61.0%	29.51	2013
Turkey	$821.80	8.9%	73.14	27.3%	224.35	63.8%	524.31	2013
Turkmenistan	$40.56	7.2%	2.92	24.4%	9.90	68.4%	27.74	2013
Turks and Caicos Islands	N/A	1.0%		22.5%		76.5%		2013
Tuvalu	$0.04	16.6%	0.01	27.2%	0.01	56.2%	0.02	2002
Uganda	$22.60	23.1%	5.22	26.9%	6.08	50.0%	11.30	2013
Ukraine	$175.50	9.9%	17.37	29.6%	51.95	60.5%	106.18	2013
United Arab Emirates	$390.00	0.6%	2.34	61.1%	238.29	38.2%	148.98	2013
United Kingdom	$2,490.00	0.7%	17.43	20.5%	510.45	78.9%	1,964.61	2013
United States	$16,720.00	1.1%	183.92	19.5%	3,260.40	79.4%	13,275.68	2013
Uruguay	$57.11	7.5%	4.28	21.5%	12.28	71.0%	40.55	2013
Uzbekistan	$55.18	19.1%	10.54	32.2%	17.77	48.7%	26.87	2013
Vanuatu	$0.83	22.4%	0.19	9.7%	0.08	67.9%	0.56	2013
Venezuela	$367.50	3.7%	13.60	35.5%	130.46	60.8%	223.44	2013

Table A-10. GDP Sector Breakdown by Country

Country	GDP (Official Exchange Rate) (USD billion)	% Agriculture	$ Agriculture	% Industry	$ Industry	% Services	$ Services	Year Est.
Vietnam	$170.00	19.3%	32.81	38.5%	65.45	42.2%	71.74	2013
Virgin Islands	N/A	1.0%		19.0%		80.0%		2003
Wallis and Futuna	N/A							
West Bank	$6.64	4.2%	0.28	17.9%	1.19	77.9%	5.17	2012
Western Sahara	N/A	N/A		N/A		40.0%		2007
Yemen	$43.89	7.7%	3.38	30.9%	13.56	61.4%	26.95	2013
Zambia	$22.24	19.8%	4.40	33.8%	7.52	46.5%	10.34	2013
Zimbabwe	$10.48	20.1%	2.11	25.4%	2.66	54.5%	5.71	2013
World	$74,310.00	6.0%	4,458.60	30.7%	22,813.17	63.3%	47,038.23	2013