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Machinery Market Potential Index

Preface

- The Market Potential Index (MPI) for specific industries intends to compare countries identified as having the highest Gross Domestic Product (GDP) globally, based on several dimensions.
- In the 2016, the number of countries used for these rankings was 89, but has increased to 97 for 2017. Countries removed from the MPI rankings include Iraq, Luxembourg, Malta, Myanmar, and Papua New Guinea; while those added are Angola, Bolivia, Cameroon, the Democratic Republic of the Congo, Côte d'Ivoire, Ethiopia, Ghana, Jordan, Kenya, Lebanon, Panama, Tanzania, and Uganda.
- The Index compares these 97 countries on six market dimensions: size, growth rate, capacity, openness, current logistics infrastructure, and country risk. In order to measure each of these dimensions, a different set of indicators has been identified for each industry. Secondary data that has been gathered from reputable sources is used for these indicators, as noted. The rankings of the countries are calculated by adding up the dimensions and weighing them based on relative importance.
- While the MPI is a very useful tool for companies in the process of researching new markets for export, it should not be used as the single source of information in the decision. MPIs are designed to support further market research and is intended to be used for verification purposes. The information in this report can be utilized as a foundation to help identify potential countries for which more detailed research should be conducted.
- The Market Potential Index is calculated with the most recent data that is available, so it is important to note that the results represent the current state of the identified 97 countries, not a forecast.

Industry specific MPIs are updated annually, and can be accessed at: <u>https://globaledge.msu.edu/mpi</u>

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Market Overview

Europe

United Kingdom

- The United Kingdom increased one place in the Machinery MPI ranking for 2017 to #4. There is relatively low mining activity that remains in the United Kingdom, so the machinery market is mostly concentrated within the construction and agricultural sectors. Construction acts as a major driver, accounting for 52.5% of the market's overall value at US\$215.9 billion, followed by agriculture at 45.9%. Out of Europe as a whole, the United Kingdom accounts for 13% of the region's construction industry.
- Non-residential construction and residential construction are similar in their total value. In 2016, the non-residential segment accounted for 41.6% of the total construction industry; worth US\$89.8 billion. This was followed by the residential segment at 37.5% and US\$80.9 billion, and the civil engineering segment at 20.9% and US\$45.2 billion.
- The construction industry in the United Kingdom has grown at a slightly higher rate than other major countries in Europe, helped by low-interest rates and government assistantship programs, like Help to Buy.¹ The Help to Buy program offers subsidies for first-time buyers in the housing market, which will continue to encourage homeownership and drive demand in the residential construction sector over the period of the program, which ends in November of 2019.²
- For agriculture in the United Kingdom, machinery is divided into three different machine categories: compact tractors with 50 metric horsepower or less, other tractors with greater than 50 metric horsepower, and combines. Non-compact tractors with more than 50 metric horsepower accounted for the largest segment, at 84.3% of agricultural machinery.³
- The United Kingdom voted to withdraw from the European Union in the 'Brexit' referendum in 2016, which is expected to have the most adverse impact on the agri-food industry. A large portion of the impact will stem from labor shortages due to increased immigration restrictions, which will inadvertently affect the demand for agricultural machinery such as tractors and combines.⁴

<u>http://advantage.marketline.com.proxy1.cl.msu.edu/Product?ptype=Industries&pid=MLIP1347-0008</u> ⁴Forbes-Britain Could Face Major Labor Shortages After Brexit:

¹MarketLine Advantage-Construction in the United Kingdom:

http://advantage.marketline.com.proxy1.cl.msu.edu/Product?ptype=Industries&pid=MLIP2226-0053 ²UK Help to Buy: <u>https://www.helptobuy.gov.uk/help-to-buy-isa/how-does-it-work/</u>

³MarketLine Advantage-Agricultural Machinery in the United Kingdom:

<u>https://www.forbes.com/sites/davidschrieberg1/2017/01/28/britain-could-face-major-labor-shortages-after-</u> brexit/#5cd6890c2fce

France

- France increased four places for the Machinery MPI rankings of 2017 to #6 and is considered one of the main players in the European machinery market. For 2016, the construction machinery segment was the most lucrative, with total revenues of \$2,737.2 million and equivalent to 53.2% of the market's overall value. The agricultural machinery segment followed closely and contributed \$2,290.5 million in revenue or roughly 44.6% of the market's value.
- In 2016, France hosted the European Championship of the Union of European Football Associations (UEFA), which is the administrative body for association football in Europe. This event boosted construction, which in turn was profitable for the French construction machinery segment and the industry as a whole.
- Another factor that will drive growth in the construction machinery segment is the French government's participation in the Paris Agreement on climate change. One of the main goals of the Paris Agreement includes the reduction of each member country's emission by 20%. This goal creates a growing demand for energy-efficient buildings and will lead to the retrofitting of 500,000 existing homes annually.⁵

Asia

China

- Remaining at the #1 ranking for the Machinery MPI for 2017, China has one of the most robust machine industries in the world. As one of the leading pillars of the Chinese economy, the machinery industry is valued at US\$3.5 trillion. Small to medium-sized enterprises (SMEs) account for the largest portion of demand for lower-end machinery and are for the most part clustered around Shanghai City, Shandong Province, Jiangsu Province, and Zhejiang Province.
- For high-end machinery, the market is mostly comprised of state-owned enterprises and large international firms. In 2013, over 500,000 people were reported to be employed by 2,023 enterprises in the machine tools industry; of which 959, or 47.4%, were owned by the Chinese government.⁶
- Drawing inspiration from Germany's "Industry 4.0" plan, the "Made in China 2025" initiative was drafted by the Ministry of Industry and Information Technology (MIIT) over two and a half years, with input from 150 experts from the China Academy of Engineering. The main goals of the "Made in China 2025" plan include shaping the industry to become driven by innovation, with an emphasis on quality and the development of green technology.

⁵MarketLine Advantage-France-Machinery:

<u>http://advantage.marketline.com.proxy2.cl.msu.edu/Product?ptype=Industries&pid=MLIP2405-0005</u> ⁶Export.Gov-China Machinery: <u>https://www.export.gov/article?id=China-Machinery</u>

The Chinese MIIT plans to highlight 10 priority sectors: information technology, automated machine tools and robotics, aerospace and aeronautical equipment, maritime equipment and high-tech shipping, modern rail transport equipment, new-energy vehicles and equipment, power equipment, agricultural equipment, new materials, and finally biopharmaceuticals and advanced medical products.⁷ The "Made in China 2025" efforts are expected to transform and upgrade these sectors of the machinery industry during the remaining years to 2025. Global firms in the machinery industry are expected to benefit from China's desire to improve their manufacturing industry, due to their reputation for creating high quality and durable products. Sectors that are projected to have the most success are die and mold, robotics, and CNC machinery.

Japan

- Japan, like China, is a renowned leader in the machinery industry. Remaining at the #3 ranking for the Machinery MPI in 2017, Japan is home to six out of the eleven firms with the highest revenue for large tool machinery manufacturing worldwide. The global rise of machine tool consumption has offered opportunities for Japanese machinery manufacturers to partner with European firms.
- Some of the leading companies in Japan have been in business for decades, much like Yamazaki Mazak Corp. which was founded in 1919, Mori Seiki in 1948, and Fanuc in 1958. The long histories of firms like these provide them with a deep market knowledge of the machinery industry.⁸
- Joining many other countries following Germany's Industry 4.0, Japan is also creating a program to advance their machinery and manufacturing industries, "Society 5.0". Japan's Society 5.0, proposed by the government in 2016 as "the 5th Science and Technology Basic Plan", in order to develop into a 'Super Smart Society'. The desire is to use the Internet of Things (IoT), big data, and artificial intelligence to permeate every aspect of their society will create a need for extremely advanced machines and will place Japan at the forefront of development for the machinery industry.⁹

North America

Canada

Although Canada decreased one ranking for the Machinery Industry MPI, it is still highly ranked at #5 for 2017. Boasting a highly developed industrial economy, Canada is home to more than 9,000 companies with a direct labor force of more than 170,000 people operating in their machinery and equipment industry. Machinery intensive industries are some of the largest drivers of the Canadian economy, especially agriculture,

⁷Center for Strategic & International Studies-Made in China 2025: <u>https://www.csis.org/analysis/made-china-2025</u> ⁸Japan Industry News-The Japanese Machinery Industry: <u>https://www.japanindustrynews.com/2016/05/japanese-machinery-industry/</u>

⁹Japan Industry News-Japan's Society 5.0-Going Beyond Industry 4.0: https://www.japanindustrynews.com/2017/08/japans-society-5-0-going-beyond-industry-4-0/

minerals, oil and gas, utilities, construction, and manufacturing.¹⁰ Of these, construction and agriculture account for the largest segments of the industry.

- Construction machinery was 64.1% of the market's overall value, with revenues of US\$5.2 billion. As of 2016, there had been a reported 8.7% increase in the investment of building new homes, which will continue to boost the demand for construction machinery and equipment. A possible hindrance of this growth may be new policies that regulate the building of new homes.
- In comparison, the agricultural machinery segment of the industry was 25.5% of the market's overall value, with revenues of nearly US\$2.1 billion. The Canadian government's Census of Agriculture for 2016 reported a decrease in the number of farms present in the country, which led to a decline in demand for agricultural machinery.¹¹

Mexico

- Mexico decreased four places to #17 for the 2017 Machinery Industry MPI ranking. Like many other countries, construction, agriculture, and oil and gas make up the majority of demand for machinery in Mexico. Firms in the industry benefitted from the lowered prices in electricity, iron, and steel. Electricity prices were cut as much as 30% between 2014 and 2015, and the oversupply from China lowered steel prices by 38% for cold rolled sheet and 47% for hot-rolled between 2011 and 2014. These low prices are expected to continue into 2018, which will continue to benefit Mexican machinery producers.¹²
- The drop in rankings from 2016 to 2017 for Mexico can potentially be attributed to reduced drilling activity in the country's oil industry in response to lowered global oil prices and heavily increasing input costs. This led to a decline in capital investments into machinery across the board, especially when coupled with a reduction in the federal budget for infrastructure development. Although the budget for federal investment into infrastructure was decreased, the construction industry encountered new commercial and residential projects. High-rise buildings and retail space developments occurred in Mexico's largest cities, like Mexico City and Monterrey.
- Lower rates of unemployment and steady wage growth have also been supportive of consumer confidence and spending, spurring the construction of new homes. The National Workers' Housing Fund an initiative of the Mexican government, doubled their maximum amount of fixed-rate home loans and lowered finance rates.¹³ These

<u>http://www.portal.euromonitor.com.proxy2.cl.msu.edu/portal/analysis/tab</u> ¹³Passport GMID-Machinery for Construction, Mining, and Quarrying in Mexico: http://www.portal.euromonitor.com.proxy2.cl.msu.edu/portal/analysis/tab

¹⁰The Canadian Trade Commissioner Service-Machinery and Equipment: <u>http://www.international.gc.ca/investors-investisseurs/sector-secteurs/machinery-machinerie.aspx?lang=eng#fnb1</u>

¹¹MarketLine Advantage-Machinery in Canada:

<u>http://advantage.marketline.com.proxy2.cl.msu.edu/Product?ptype=Industries&pid=MLIP2405-0003</u> ¹²Passport GMID-Agricultural and Forestry Machinery in Mexico:

developments in the commercial and residential construction industries supported by the Mexican government have in turn cushioned the machinery industry despite the downturn in the agricultural and oil segment's machinery demand.

Drawing inspiration from Germany's "Industry 4.0" plan, the "Made in China 2025" initiative intends to shape the machinery industry in China to become driven by innovation, with an emphasis on quality and the development of green technology. The 10 machinery sectors that will be focused on are information technology, automated tools and robotics, aerospace, high-tech shipping, modern rail transport, new-energy vehicles, power, agriculture, new materials, biopharmaceuticals, and advanced medical products.

Singapore

South

Korea

Switzerland

Germany

Netherlands

France

Canada



China

Japan

Like China and Germany, Japan is creating a program to advance their machinery and manufacturing industries, "Society 5.0". This will increase demand for equipment in IoT, big data, and artificial intelligence.



The construction and agriculture industries act as two of the main drivers of demand for machinery in the United Kingdom. The construction industry in the UK has grown at a slightly higher rate than other countries in Europe, helped by low-interest rates and government assistantship programs. The vote to leave the European Union in 2016 is expected to have the most adverse effects on the agri-food industry, which would also impact the demand for agricultural machinery.

Machinery intensive industries are some of the largest drivers of the Canadian economy, especially agriculture, minerals, oil and gas, utilities, construction, and manufacturing. Construction accounts for the largest segment of the machinery industry, at 64.1% of the market's overall value. There had been a reported 8.7% increase in the investment of building new homes, which will continue to boost demand for construction machinery and equipment.

2017 Machinery Top 10 Markets

International Business Center Michigan State University

Results of the 2017 Machinery MPI

	OVERALL RANK	Market Size (30/100) INDEX	Market Growth Rate (15/100) INDEX	Market Capacity (10/100) INDEX	Market Openness (15/100) INDEX	Logistics Infrastructure (15/100) INDEX	Country Risk (15/100) INDEX
China	1	100	49	100	63	78	60
China	2	43	49 50	46	85	89	94
Germany	2	35	50	84	87	67	94
Japan		20	50		93	89	87
United Kingdom	4			44			
Canada	5	17	51	49	100	84	88
France	6	20	49	54	87	79	88
Netherlands	7	13	47	51	88	100	92
Singapore	8	10	47	46	98	81	88
Switzerland	9	7	48	74	85	68	100
Korea, Rep.	10	18	52	39	77	71	79
Ireland	11	4	64	75	88	59	86
Belgium	12	8	48	21	87	92	89
Spain	13	11	52	26	82	80	77
Sweden	14	6	44	35	86	78	96
Italy	15	15	49	27	80	61	77
Hong Kong	16	11	20	68	90	77	84
Mexico	17	17	60	15	86	57	51
Denmark	18	4	52	31	84	73	91
Norway	19	4	49	40	89	56	97
Austria	20	7	49	27	84	62	94
United Arab E.	21	7	60	27	83	72	69
Finland	22	4	43	29	89	66	90
Australia	23	8	46	38	82	35	91
Czech Republic	24	7	52	12	82	49	85
Poland	25	7	54	14	82	49	76
India	26	16	54	18	68	36	57
Israel	27	4	56	28	80	43	78
Portugal	28	3	49	13	84	62	77
Estonia	29	2	52	12	85	48	86
Malaysia	30	6	51	10	81	56	69
Slovakia	31	4	60	12	81	36	78
Lithuania	32	2	63	10	81	47	73
Saudi Arabia	33	8	63	15	69	44	60
Hungary	34	5	56	9	83	40	67
Chile	35	3	47	16	81	47	76

	OVERALL	ERALL Market Size (30/100)		Market Capacity (10/100)	Market Openness (15/100)	Logistics Infrastructure (15/100)	Country Risk (15/100)	
	RANK	INDEX	INDEX	INDEX	INDEX	INDEX	INDEX	
Slovenia	36	2	48	14	83	48	76	
Latvia	37	2	50	10	81	44	75	
Turkey	38	9	55	12	70	48	44	
Philippines	39	5	81	7	71	6	58	
Panama	40	1	39	12	84	77	58	
Dominican Rep.	41	1	66	6	87	45	42	
Thailand	42	8	51	8	75	30	54	
Vietnam	43	6	72	7	68	28	43	
Morocco	44	3	56	5	73	49	57	
Romania	45	4	54	9	78	29	59	
Peru	46	3	50	8	79	37	57	
Russia	47	13	45	24	63	30	39	
Greece	48	2	49	13	79	47	50	
El Salvador	49	1	55	4	92	36	43	
Bulgaria	50	2	58	7	77	23	58	
Costa Rica	51	1	45	10	90	28	59	
Croatia	52	2	51	9	81	43	46	
Indonesia	53	9	52	10	68	9	54	
Kuwait	54	2	57	18	66	24	61	
Cote d'Ivoire	55	1	85	2	67	35	28	
Guatemala	56	1	58	4	85	35	41	
Colombia	57	3	45	9	78	41	51	
Oman	58	1	50	10	75	40	55	
Bahrain	59	1	51	14	77	42	48	
Uruguay	60	1	44	12	75	40	59	
Brazil	61	10	40	38	56	30	39	
South Africa	62	4	43	7	72	43	49	
New Zealand	63	2	1	22	88	34	93	
Cyprus	64	1	36	13	77	31	65	
Qatar	65	3	23	33	66	42	67	
Cambodia	66	1	100	2	53	4	29	
Jordan	67	1	53	4	79	29	39	
Sri Lanka	68	1	59	4	73	24	38	
Honduras	69	1	48	3	81	38	35	
Ecuador	70	2	45	6	78	47	27	
Ethiopia	71	1	97	2	54	1	20	
Bolivia	72	1	64	3	76	4	34	
Kenya	73	1	54	4	69	26	38	

	OVERALL	Market Size (30/100)	Market Growth Rate (15/100)	Market Capacity (10/100)	Market Openness (15/100)	Logistics Infrastructure (15/100)	Country Risk (15/100)	
	RANK	INDEX	INDEX	INDEX	INDEX	INDEX	INDEX	
Kazakhstan	74	3	48	8	83	12	31	
Serbia	75	1	46	5	73	17	38	
Algeria	76	3	53	5	54	18	39	
Tunisia	77	2	47	5	66	17	40	
Egypt	78	3	52	6	50	45	25	
Azerbaijan	79	2	49	6	66	21	30	
Pakistan	80	3	69	2	44	26	21	
Uzbekistan	81	3	58	4	71	6	16	
Bangladesh	82	3	64	4	52	7	28	
Lebanon	83	1	53	7	64	26	20	
Paraguay	84	1	42	3	73	18	32	
Argentina	85	4	45	12	43	32	32	
Cuba	86	3	53	6		34	1	
Uganda	87	1	54	1	67	7	28	
Nicaragua	88			2	76	23	24	
Belarus	89	2	42	6	79	22	7	
Angola	90	2	64	7	52	4	16	
Ghana	91	1	41	3	58	20	36	
Tanzania	92	1	46	2	56	12	30	
Ukraine	93	2	30	5	72	24	12	
Nigeria	94	3	47	5	47	15	15	
Cameroon	95	1	52	2	36	6	27	
Venezuela	96	4	41	5	45	18	1	
Congo, Dem. Rep.	97			1	1	4	9	

* Overall Rank is calculated by weighting the six dimension values. For Index values, values of the countries are converted into a 1-100 scale based on their relative magnitudes in each of the six dimensions. An index value of 100 indicates a country with the largest (or most favorable) value in a dimension whereas an index value of 1 indicates the smallest (or least favorable). While both the overall rank and index values show the rank order of the countries, the index values also indicate the magnitude of each country in relation to others in that order.

Assumptions

- The machinery manufacturing industry provides essential and highly sophisticated technology for a wide range of other industries; including but not limited to agriculture, construction, mining, and energy. Due to the industry's large scope, the total value of manufacturing production of countries is considered to be a good indicator of the market size for the machinery industry. On the other hand, consumption values of all machinery products are used as an indicator of the market size. Since the consumption values are not readily available as secondary data, they are calculated by subtracting the machinery products exports from the total of machinery production and imports.
- Market growth rate is measured by calculating the Compounded Annual Growth Rate (CAGR) of each market size indicator for the last 5 years. Along with the other generic export related indicators, Tariff data for Harmonized System (HS) code 84 (Nuclear Reactors, Boilers, Machinery and Mechanical Appliances; parts thereof) is used for the measurement of market openness dimension.

Dimension	Weight	Measures Used
Market Size	30	 Consumption of Machinery=[Production (2016)¹ + Imports (2016)²]-Exports (2016)²] Imports of Machinery (2016)² Manufacturing, Value Added (2015)³
Market Growth Rate	15	 CAGR of Consumption of Machinery (2011-2016)^{1,2} CAGR of Imports of Machinery (2011-2016)² CAGR of Manufacturing, Value Added (2010-2015)³
Market Capacity	10	 Foreign Direct Investment, Net Inflows (2015)³ GNI Per Capita (2016)³ R&D Expenditure (2016)¹
Market Openness	15	 Applied Tariff Rate on Machinery (2017)⁴ Burden of Customs Procedure (2016)³ Cost to Import, border compliance (2016)³ Cost to Import, documentary compliance (2016)³

Indicators and Resources

		 Imports of Machinery from US as a Share of Global Imports (2016)³
Logistics Infrastructure	15	 Distance of Country from US (2016)⁵ Linear Shipping Connectivity Index (2016)³ Logistics Performance Index (2016)³ Quality of Port Infrastructure Index (2016)³
Country Risk	15	 Business Risk Rating (2016)⁸ Economic Risk Rating (2016)⁷ Intellectual Property Rights Protection (2017)⁹ Political Risk Rating (2016)⁶

Data used are those available for most recent year. All sources were accessed in May-August 2017.

- ¹ Passport GMID, <u>Global Market Information Database</u>
- ² UN Comtrade, <u>Commodity Trade Statistics Database</u>
- ³ World Bank, <u>World Development Indicators</u>
- ⁴ World Trade Organization (WTO), Tariff Database
- ⁵ Happyzebra, <u>Distances</u>
- ⁶ Credendo, <u>Country Risks</u>
- ⁷ Coface, <u>Economic Studies</u>
- ⁸ Swiss Export Risk Insurance, <u>Cover Practice for Countries and Banks</u>
- ⁹ International Property Rights Index, <u>2016 IPRI Report</u>

Year To Year Comparison

	RA	NK				RANK
Country	2017	2016	2014	Country	Country 2017	<i>Country</i> 2017 2016
China	1	1	1	El Salvador	13	13 13
Germany	2	2	2	Bulgaria	Bulgaria 50	Bulgaria 50 59
Japan	3	3	3	Costa Rica	Costa Rica 51	
United Kingdom	4	5	7	Croatia		
Canada	5	4	5	Indonesia	Indonesia 53	
France	6	10	11	Kuwait	Kuwait 54	Kuwait 54 65
Netherlands	7	8	8	Cote d'Ivoire	Cote d'Ivoire 55	Cote d'Ivoire 55
Singapore	8	6	4	Guatemala	Guatemala 56	Guatemala 56 41
Switzerland	9	12	9	Colombia	Colombia 57	Colombia 57 52
Korea, Rep.	10	11	10	Oman	Oman 58	<i>Oman</i> 58 46
Ireland	11	17	45	Bahrain	Bahrain 59	Bahrain 59 67
Belgium	12	16	32	Uruguay		
Spain	13	26	39	Brazil	Brazil 61	Brazil 61 64
Sweden	14	15	15	South Africa		
Italy	15	28	35	New Zealand	5	,
Hong Kong	16	7	6	Cyprus		
Mexico	17	13	14	Qatar	51	51
Denmark	18	18	28	Cambodia		
Norway	19	16	20	Jordan		-
Austria	20	22	27	Sri Lanka		
United Arab Emirates	20		18	Honduras		
		9		Ecuador		
Finland	22	27	21			
Australia	23	21	12	Ethiopia Dolinia		
Czech Republic	24	30	33	Bolivia		
Poland	25	31	49	Kenya		
India	26	32	36	Kazakhstan		
Israel	27	38	17	Serbia		
Portugal	28	44	55	Algeria	_	5
Estonia	29	24	41	Tunisia		
Malaysia	30	29	25	Egypt		551
Slovakia	31	40	46	Azerbaijan		
Lithuania	32	34	56	Pakistan	Pakistan 80	
Saudi Arabia	33	19	24	Uzbekistan	Uzbekistan 81	Uzbekistan 81 88
Hungary	34	51	60	Bangladesh	Bangladesh 82	Bangladesh 82 71
Chile	35	37	23	Lebanon	Lebanon 83	Lebanon 83
Slovenia	36	55	61	Paraguay	Paraguay 84	Paraguay 84 75
Latvia	37	36	59	Argentina		
Turkey	38	33	44	Cuba	-	
Philippines	39	53	71	Uganda	Uganda 87	Uganda 87
Panama	40	55	,	Nicaragua		-
Dominican Republic	41	57	42	Belarus	5	5
Thailand	42	48	30	Angola		
Vietnam	42	43	68	Ghana		_
Morocco	43 44	56	50	Tanzania		
Romania			50 65	Ukraine		
	45	54		Nigeria		
	46	43	31	Cameroon		
Peru				Cameroon	Comproon 45	
Russia Greece	47 48	58 76	19 72	Venezuela		

For More Information

For the indexing methodology, please refer to:

"Measuring the Potential of Emerging Markets: An Indexing Approach" - S. Tamer Cavusgil, Business Horizons, January-February 1997, Vol. 40 Number 1, 87-91

"Complementary Approaches to Preliminary Foreign Market Opportunity Assessment: Country Clustering and Country Ranking" - S. Tamer Cavusgil, Tunga Kiyak and Sengun Yeniyurt, <u>Industrial Marketing Management, October 2004, Volume 33, Issue 7, 607-617</u>