



2016 Global Cold Storage Capacity Report



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Acknowledgements

The Global Cold Chain Alliance (GCCA) would like to recognize the author of this report:

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Introduction

This report provides an update on refrigerated warehouse capacity in 52 countries using information collected from international offices of the Global Cold Chain Alliance (GCCA). The primary data source was a survey administered in spring 2016 by the GCCA staff. In addition, official government reports were the sources for information on the United States (U.S. Department of Agriculture) and India (India Department of Agriculture, Cooperation and Farmers Welfare).

Summary of the Findings

Global capacity increased steadily. The total capacity of refrigerated warehouses was 600 million cubic meters in 2016, an increase of 8.6% since 2014 (4.2% annualized growth rate). Considerable new construction in emerging markets explains most of the increase in refrigerated warehousing space.

Construction of new refrigerated warehouse space was particularly strong in China (more than 30 million cubic meters) and India (10 million cubic meters). Construction also occurred in markets that previously had little cold storage capacity, namely Uzbekistan and Turkey.


In addition to new construction, some of the increase in global capacity was due to more comprehensive reporting. To illustrate the enhanced reporting, approximately 11 million cubic meters of additional refrigerated warehouse capacity has been added to the GCCA database from countries that were included for the first time in 2016. The newly added countries were South Korea, Peru, Mauritius, Ecuador and Kenya.

Reports from Europe indicated that refrigerated warehouse space declined in 2016 in several countries. Turkey and Great Britain were exceptions. In both Turkey and Great Britain, new construction was reported. The expansion in Great Britain was largely due to retailers' construction of distribution centers for private use.

The United States, Mexico, and Canada each indicated growth in refrigerated warehouse capacity since 2014. In North America, the total refrigerated warehouse space was 6 million cubic meters larger in 2016 than that reported in 2014, an increase of 4.6% since 2014 (2.3% annualized growth rate).

Variation in service levels across countries. To facilitate comparisons across countries, a market development index was calculated. On a per-capita basis, globally, there was an average of 0.2 cubic meters of refrigerated warehouse space per urban resident. This figure is the aggregate across the countries for which data are available in 2014 or 2016. The status of refrigerated warehouse capacity was uneven across the high-income and low-to-middle income countries. In the more developed markets, refrigerated warehousing serves local consumers through the distribution and retail sale of frozen and chilled food. Per capita market penetration in these better-served markets was typically in the range of 0.3 to 0.5 cubic meters per urban resident. In countries with greater levels of the market development index, the refrigerated warehousing was used for import-export trade as well as in domestic consumer markets. The market development index ranged between 0.6 to 1.0 cubic meters per capita in the trading countries.

Trend analysis of the market development index since 2012 indicates that in most of the emerging markets (middle-income countries), refrigerated warehouse capacity largely has kept pace with the growing population. However, some countries that had significant gains in service level, according to the trend in the index, were at low levels of per capita market size. This indicates the country was underserved in spite of the recent improvements.



Drivers of refrigerated warehouse capacity growth. A number of factors influenced growth in refrigerated warehouse capacity, such as household income; growth of the urban population; sales in supermarket retail outlets; consumption of meat, dairy products, and frozen foods; and quality of roadway and port infrastructure. Household income was proven to be positively associated with the level of refrigerated warehouse market development across the countries in the survey.

Changes in the number of modern food retail outlets and a transportation quality index were included in quantitative models, but there was no clear statistical evidence about the linkage of these two variables to refrigerated warehouse development.

Limitations and Methodological Notes

The figures in this report are the most complete available to document the trends in the refrigerated warehousing industry. Certain limitations should be noted when the aggregations and growth trends are interpreted.

Units of measure. There is the potential for error because conversion factors between quantity units must be applied. Most of the respondents to this survey are collecting information in common cubic units, so the conversion issues have affected a limited number of responses. The countries that report data in tonnage or pallets are indicated in the appendix.

Public, for-hire warehouses are engaged in the market and often affiliated with the GCCA, therefore it is likely that the respondents to this inquiry are well-informed about space in public refrigerated warehouse (PRWs). Warehouses that were operated privately may not have been thoroughly covered by the information sources used in this inquiry, in spite of efforts to obtain a breakout of public space and private space.

Growth rates. Most percentage changes in the report are compound annual growth rates (CAGRs). Compounding is a smoothing method that converts a series of values over time to an annualized figure. All of the CAGRs presented are historical figures and are not intended to serve as forecasts of future changes in refrigerated warehouse capacity. The formula for calculation of the CAGR is provided in the Appendix.



Capacity and Growth of Refrigerated Warehousing by Country

The total capacity of refrigerated warehouses worldwide reached 600 million cubic meters in 2016, an increase of 8.6% from 2014. The global growth rate since 2014 was 4.2% on an annual compound basis. A large amount of new construction in emerging market economies explains most of the increase in refrigerated warehousing space.

China was the leading location of new construction, with 31 million cubic meters of additional space reported. India was the largest single country market, at 141 million cubic meters total (21 million cubic meters in new facilities). Along with India, the United States, and China each had more than 100 million cubic meters of refrigerated warehouse capacity as of 2016, according to the GCCA sources (Figure 1).

Among the smaller country markets, Uzbekistan, Turkey, and Mexico reported substantial capacity growth, by 1.6 million cubic meters in Mexico and 2.4 million cubic meters in Turkey and Uzbekistan.

In North America, the total refrigerated warehouse space was 6 million cubic meters larger in 2016 than that reported in 2014, an increase of 4.6% since 2014 (2.3% annualized growth rate). The United States industry accounted for 3.2 million additional cubic meters of capacity.

Some of the increase in refrigerated warehouse capacity is attributable to reporting from countries that had not previously been included in the database. Reporting changes accounted for approximately 11 million cubic meters of the capacity additions to the GCCA database. The new countries reported were South Korea, Peru, Mauritius, Ecuador and Kenya.

Refrigerated warehouse capacity levels in most European countries fell in 2016 compared with 2014. Cold storage capacity in Europe totaled 112 million cubic meters. Turkey and Great Britain were exceptions to the downward trend. In Turkey, GCCA sources noted construction projects in progress and more construction supplies on order. In Turkey, over 2.4 million cubic meters of new construction occurred over the last two years.

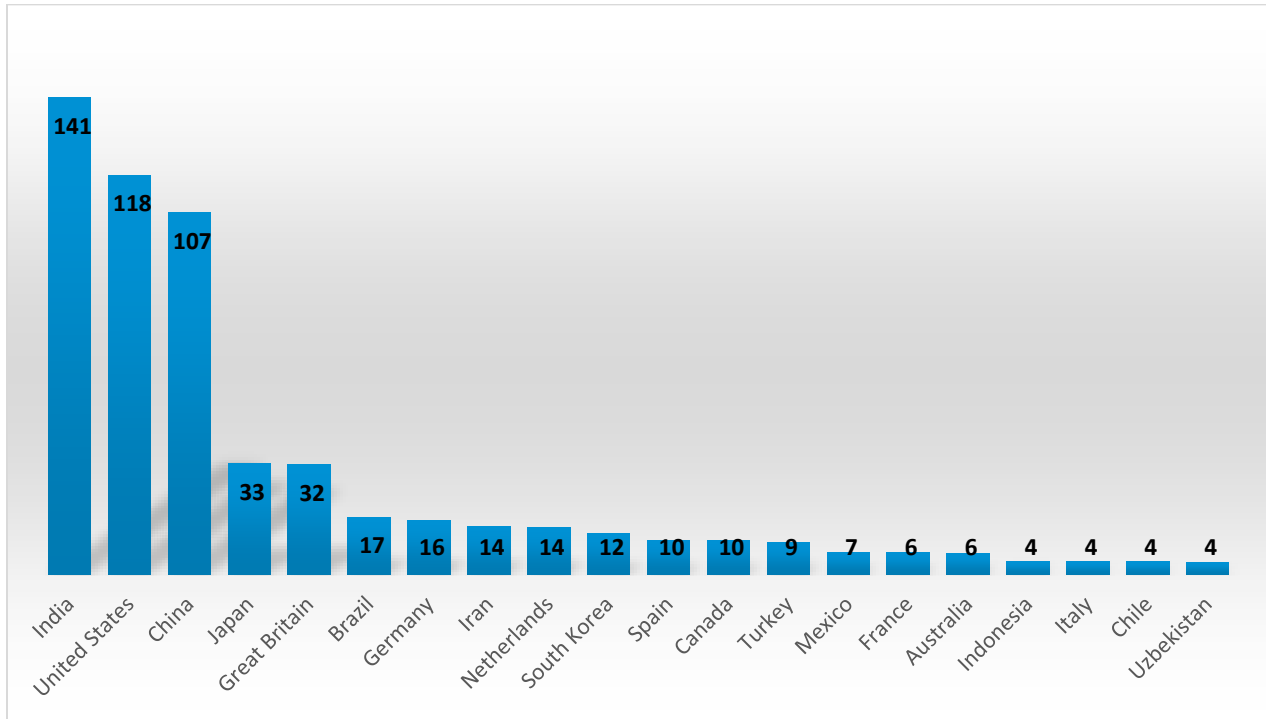
Great Britain was a mixed picture. Total capacity reported was 32 million cubic meters, a substantial increase due in part to better information on the privately operated warehouses. There were many aged facilities that are operational today, yet because of the dated technologies, were not expected to be competitive for much longer. The public, for-hire segment of the market in Great Britain was estimated at 7 to 8 million cubic meters, or approximately 23% of the national capacity. The private cold storage business dominated market share over the public warehouses and private warehouses reportedly accounted for nearly all of the new construction in Britain.

The figures shown in this report were from 2016 when available. In some countries, an updated capacity estimate was not available and in those cases, the reported data were from 2014. The data included all refrigerated space in the respective markets, both the privately managed warehouses that a food processing company owns and the third-party logistics facilities (public warehouses) available for hire.

Warehouses under government ownership are included in the nationwide capacity figures reported in this study. While government ownership of warehouses is not widespread, recent reports indicate that government warehouses were important in a few countries. For example, government-owned facilities were 50% of total capacity in Kenya, and 15% of total capacity in Indonesia and Kuwait. In India, there are indications from official sources and the business press that the central government provided assistance for new cold chain construction projects, although it is not clear whether the warehouses are

operated as private enterprises or government operations. According to GCCA sources, a government support program in Turkey was a driver of the increase in refrigerated warehouse space.


Figure 1:
Capacity of Refrigerated Warehouses, Twenty Largest Country Markets, 2014 and 2016 as available, in Million Cubic Meters.



Market Development Index

The ranking of capacity by country shown in Figure 1 (above) is connected with the nation’s population and does not provide a complete indicator of service levels relative to the needs in the market. A market development index (MDI) is necessary to account for population differences across countries. The benchmark of market penetration used by the GCCA is the ratio of refrigerated warehouse capacity to urban population. The rationale for the MDI being based on urban population is that the middle class population, which has the purchasing power to buy value-added food products, tends to be concentrated in urban or metropolitan locations. It would be preferable to have an indicator that is specifically related to consumers’ purchasing power, but there is no available data source for the size of the middle class population on a country-by-country basis. Therefore, the urban population serves as a rough proxy for the population needing to be served.

The rank of country markets according to the MDI of refrigerated warehousing indicates substantial variation across the developed and developing countries (Table 1). The MDI average globally was 0.2 cubic meters per urban resident, but the range across countries was as high as 0.96 cubic meters per urban resident to as low as 0.002 cubic meters per urban resident.



The interpretation of the MDI should take into account that, in some countries, refrigerated warehouse capacity serves the international trade of goods in addition to meeting domestic needs. In the trade-oriented economies, MDI was relatively high compared with a country that did not export significant amounts of food. The trading countries built capacity for production and storage of the goods to be shipped internationally. The MDI does not have an adjustment to take the international marketing dimension into account.

According to the country statistics in Table 1, The Netherlands had the largest ratio of capacity to urban population, at 0.96 cubic meters per capita of refrigerated capacity in 2016. Other leading countries that had more than 0.3 cubic meters refrigerated warehouse space per urban resident were Great Britain, New Zealand, United States, Mauritius, Canada, India, and Uzbekistan (Figure 2). In Uzbekistan, refrigerated warehouse capacity expanded rapidly recently to serve export trade, according to industry sources.

India is a very special case in terms of its market development. India placed in the highest-ranked group of countries according to the MDI (Figure 2). And, as a sign of favorable market development, the MDI in India rose from 0.30 in 2010 to 0.33 in 2016. There was new construction to explain the rise in the Indian market. According to official government sources, new warehouses with nearly 5 million metric tons of capacity recently entered the market in India. However, not all of the current warehouse capacity was commercially active at the end of 2014 (India Ministry of Agriculture, Cooperation and Farmers Welfare) yet it is maintained on the inventory.

Further, India's population is not highly urbanized, and as a result, the measure of market penetration for India was influenced by the capacity additions relative to the smaller share of urban population base in India. In comparison to more urbanized emerging markets like China or Egypt, the MDI for India should be interpreted carefully.

Table 1:**Refrigerated Warehouse Capacity and Market Development Index, by Country, 2012-2016 as Available**

Country	2012		2014		2016	
	Million m ³	m ³ per urban resident	Million m ³	m ³ per urban resident	Million m ³	m ³ per urban resident
Afghanistan	-	-	0.024	0.003	0.0181	0.002
Australia	6.281	0.308	5.083	0.245	6.04	0.281
Austria	1.000	0.174	1.000	0.174	-	-
Bangladesh	0.129	0.003	0.129	0.003	-	-
Belgium	2.500	0.232	2.720	0.250	2.70	0.245
Brazil	7.055	0.043	16.050	0.094	16.83	0.095
Canada	7.602	0.270	8.850	0.310	9.91	0.337
Chile	2.328	0.149	3.658	0.232	3.658	0.232
China	-	-	76.080	0.107	107	0.143
Colombia	0.850	0.024	0.100	0.003	-	-
Denmark	3.000	0.613	3.000	0.613	-	-
Dominican Republic	-	-	0.024	0.003	-	-
Ecuador ^N	-	-	-	-	0.043	0.004
Egypt	-	-	3.25	0.089	-	-
El Salvador	-	-	0.042	0.010	0.02	0.005
Ethiopia	0.024	0.002	-	-	-	-
Finland	1.000	0.216	1.000	0.216	.039	.085
France	15.500	0.282	15.500	0.282	6.29	0.111
Germany	23.950	0.395	23.950	0.395	16.00	0.265
Great Britain	24.646	0.490	24.646	0.490	32.37	0.624
Greece	1.200	0.171	1.200	0.171	0.7	0.102-
Guatemala	-	-	0.035	0.005	-	-
Hungary	0.292	0.043	-	-	-	-
India	-	-	130.720	0.328	141.13	0.335
Indonesia	0.021	0.00 ¹	12.320	0.110	3.87	0.028
Iran ^N	-	-	14.000	0.253	-	-
Ireland	2.200	0.785	-	--	-	-
Italy	4.500	0.107	4.500	0.107	3.8	0.09
Japan	-	-	32.650	0.277	-	-
Kenya ^N	-	-	-	-	0.0215	0.002
Kuwait	-	-	0.281	0.069	0.33	0.082
Libya	-	-	0.250	0.052	-	-
Mauritius ^N	-	-	-	-	0.22	0.436
Mexico	3.398	0.039	4.869	0.053	6.5	0.065
Morocco	1.591	0.083	1.700	0.086	1.7	0.082
Namibia	-	-	0.150	0.165	-	-
Nepal	0.259	0.042	-	-	-	-

Table 1, Continued:**Refrigerated Warehouse Capacity and Market Development Index, by Country, 2012-2016 as Available**

Country	2012		2014		2016	
	Million m ³	m ³ per urban resident	Million m ³	m ³ per urban resident	Million m ³	m ³ per urban resident
Netherlands	16.025	1.144	-	-	13.7	0.958
New Zealand			1.712	0.44		
Nicaragua	-	-	0.00 ¹	0.00 ²	-	-
Nigeria	-	-	0.04	0.00 ²	-	-
Norway	1.500	0.375	-	-	-	-
Oman	-	-	0.021	0.008	-	-
Panama	-	-	0.137	0.046	-	-
Peru	0.437	0.019	-	-	2	0.081
Poland	0.800	0.034	-	-	-	-
Portugal	1.400	0.212	-	-	0.42	0.064
Romania	-	-	0.292	0.027	0.5-	0.046
Saudi Arabia	1.892	0.084	1.395	0.058	-	-
South Africa	-	-	0.323	0.010	0.47	0.013
South Korea ^N	-	-	-	-	12.0	0.281
Spain	7.200	0.200	-	-	10	0.276
Sweden	1.500	0.186	-	-	2.0	0.239
Switzerland	1.184	0.201	-	-	1.5	0.248
Tanzania	0.022	0.002	-	-	-	-
Tunisia			1.310	0.179	-	-
Turkey	1.312	0.025	6.804	0.127	9.24	0.165
Ukraine	0.840	0.027	-	-	-	-
United States	112.131	0.431	114.851	0.438	118.07	0.440
Uruguay	0.980	0.312	-	-	-	-
Uzbekistan	0.258	0.024	1.075	0.102	3.54	0.327
Yemen	0.009	0.001	0.057	0.007	-	-

-- Not available.

m³ -cubic meters.

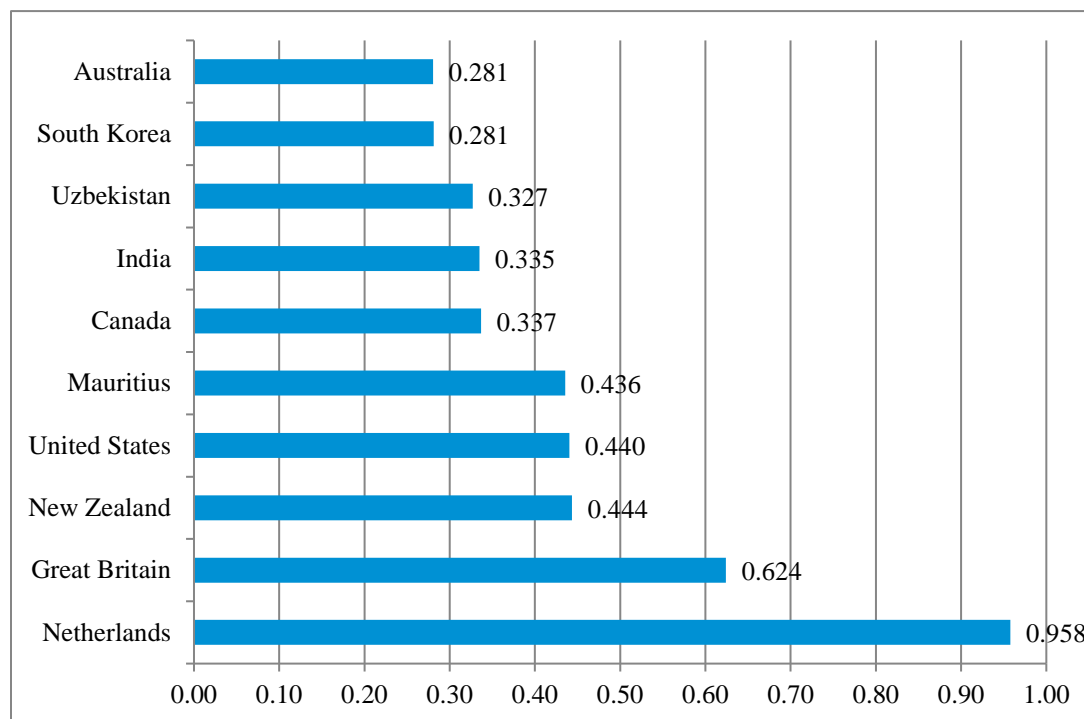
^N -Indicates countries that are new to GCCA database in 2016.

¹ -Less than 0.001 million m³.

² -Less than 0.005 m³ per capita.

Figure 2:

Refrigerated Warehouse Market Development Index (Capacity in Cubic Meters per Urban Resident), for Countries in the High Range of the Index, 2014 or 2016.



The countries categorized as medium-to-high level of cold storage market penetration included a mix of developed countries and lower-income countries (Figure 3). There were two emerging market nations, Turkey and China, along with higher-income countries (France, Spain, and Japan). Namibia, Tunisia, and Chile also ranked in the medium-to-high group based on the refrigerated warehouse capacity per urban population. The global average MDI of 0.2 cubic meters per urban resident was in the mid-range of this group of countries.

The third-ranked group (medium-to-low market penetration) comprised countries that had 0.05 to 0.10 cubic meters per urban resident (Figure 4). Italy, Greece, Brazil and Egypt were middle-to-high income countries with relatively low cold storage capacity.

The lowest-ranked countries each had fewer than 0.10 m³ of cold storage per urban resident (Figure 5). The list of low-index cold storage markets included: Kenya, South Africa, and Indonesia. Some of these countries reported fast growth in refrigerated warehouse space but the total capacity level was small relative to the size of the urban population.

Figure 3:

Refrigerated Warehouse Market Development Index (Capacity in Cubic Meters per Urban Resident), for Countries in the Medium-to-High Range of the Index, 2014 or 2016.

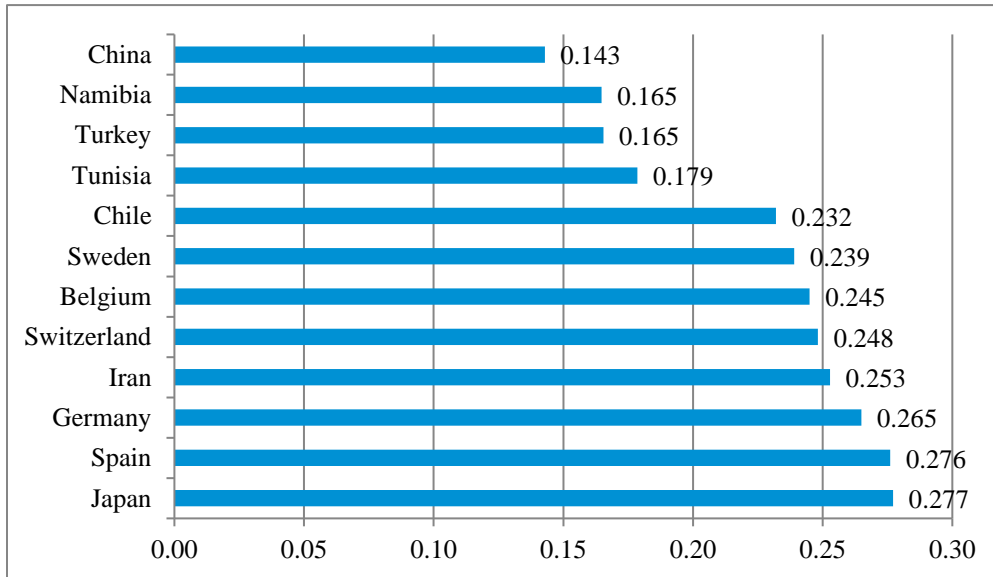


Figure 4:

Refrigerated Warehouse Market Development Index (Capacity in Cubic Meters per Urban Resident), for Countries in the Medium-to-Low Range of the Index, 2014 or 2016.

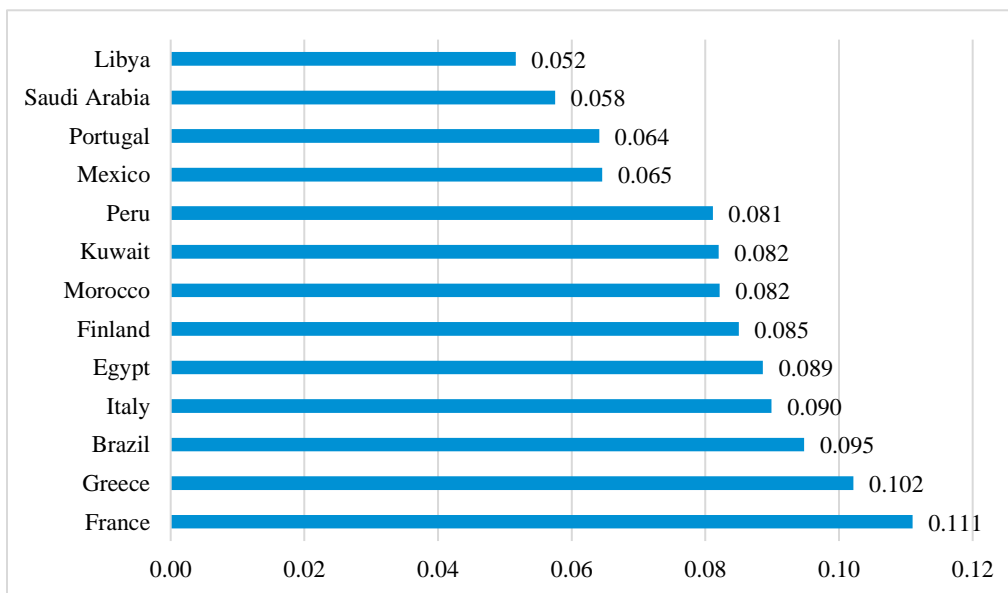
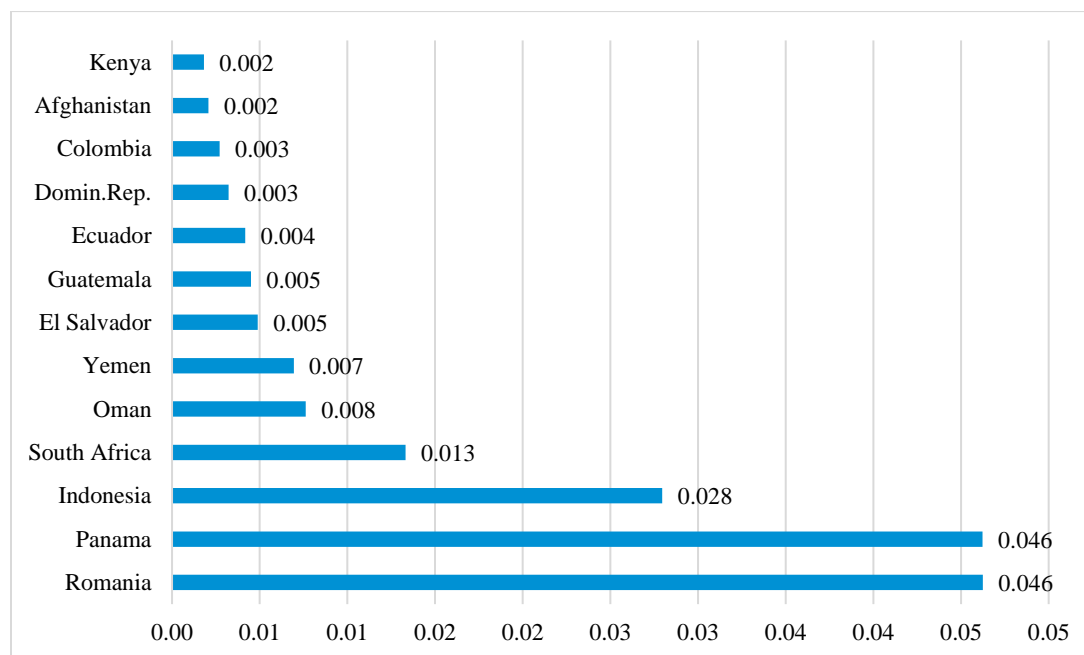


Figure 5:
Refrigerated Warehouse Market Development Index (Capacity in Cubic Meters per Urban Resident),
for Countries in the Low Range of the Index, 2014 or 2016.




Economic Development Analysis

The charts in the previous section demonstrate that the ranking of countries in terms per capita capacity largely is a story about economic development. In order to assess the influence of economic development another way, statistical models were constructed to relate refrigerated warehouse capacity to the per-capita income in the country. The statistical analysis is based on a cross-sectional framework in which the current year MDI is explained by the current year income (per capita) in each country. There is strong statistical association between refrigerated warehouse capacity and per capita income (0.015 cubic meters for an additional \$1,000 per capita annual income in the country). This is interpreted against the global average of 0.2 cubic meters per capita and levels of .07 to .08 for the countries in the medium-to-low range of the rankings shown in Figure 4.

In addition to the cross-section analysis, further examination of the trends in the MDI by country was warranted to check on two issues. First, the influence of trend population growth was considered because of the possibility that investments in infrastructure might have been overtaken by rapid population growth. If a country's urban population had grown faster than refrigerated warehouse capacity in the last two years, the MDI would have declined. Instead, in nearly all the countries for which data were available, the index of market development grew between 2014 and 2016 (Table 2, middle column).

Two exceptions were India and Brazil, which experienced negligible market development. Urban population grew nearly as fast as refrigerated warehouse space. When one pairs this fact with the already low MDI ranking for Brazil (Figure 4), there is clearly unmet need in these two large markets.



Uzbekistan posted remarkable growth in the MDI, by 219%. The other countries with strong improvement in the market penetration of cold storage were in the range of 30% growth of the MDI (South Africa, China, and Turkey).

A second trend analysis involved study of the associations between the retail food industry and the refrigerated warehousing industry. The reasoning for focusing on the food system is that supermarket sales were correlated with household income and the multivariate statistical models could not readily differentiate the two factors. A country-by-country tabular presentation revealed patterns shown in Table 2. Importantly, the growth in the MDI followed the expansion of supermarket outlets as a rule. In every country except China, the leading indicator—percentage change in supermarket outlets—rose faster than the percentage change in the MDI. With the exception of India, in countries where the rate of supermarket expansion exceeded 25%, the refrigerated warehouse market index grew 20% or more (Table 2). The fastest growth in supermarket outlets was reported in Uzbekistan, South Africa, and Brazil. Figure 6 provides an illustration of the explosive growth in supermarkets in South Africa and Brazil.

In Australia, Canada, and the United States, there was modest expansion of the supermarket sector, which is consistent with the high economic development level of these countries. Yet the MDI increased by 9% in Canada and 15% in Australia. These two countries' capacity per capita expanded much faster than other countries at similar economic development levels.

The implication of growth in the MDI as it might be interpreted for economic development and investment potential depends partly on the level of the MDI and correlated indicators, because growth rates will be very high when the changes are calculated from low base amounts. For example, Mexico and South Africa were in the lower ranked countries in terms of MDI. So, the large percent change in the MDI was a positive sign but mitigated by the low starting point. (See Figure 4 and 5, respectively, for the ranking of Mexico and South Africa).

Table 2:

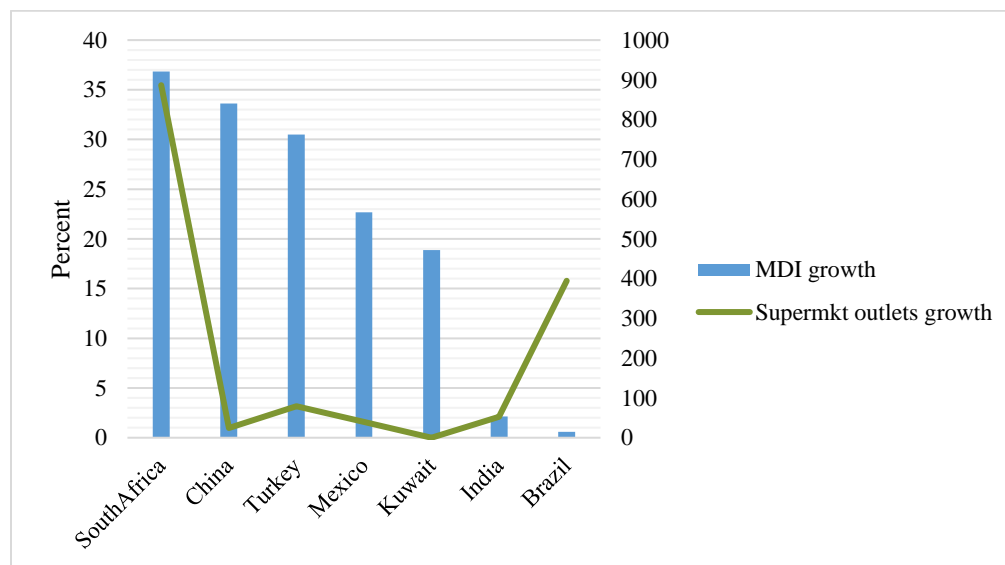
Growth in Refrigerated Warehouse Market Development Index Compared with Growth in Supermarkets, Selected Countries, 2014-2016

	% change capacity	% change in MDI	% change in supermarket outlets
	2016 compared to 2014		2013 compared to 2011
Uzbekistan	229%	219%	271%
South Africa	46%	37%	887%
China	41%	34%	24%
Turkey	36%	30%	79%
Mexico	33%	23%	40%
Kuwait	17%	19%	0
Australia	19%	15%	2%
Canada	12%	9%	9%
India	8%	2%	52%
Brazil	5%	1%	395%
United States	3%	1%	-2%

MDI = market development index, calculated as capacity / urban population.

Figure 6:

Growth in Refrigerated Warehouse Market Development Index Compared with Growth in Supermarkets, Selected Countries, 2014-2016





Growth in Capacity

The rates of change in refrigerated warehouses over various time periods are reported in this section in the form of compounded annual growth rates (CAGRs). The CAGR serves to smooth the relative changes over a number of years into a figure that represents an annual average. The smoothed percentage growth allows one to overlook apparent volatility in year-to-year that might result from construction of large new facilities into small markets.

Trends 2014-2016. As of 2016, Turkey and China experienced rapid expansion in refrigerated warehouse capacity, consistent with the situation in 2014 when the last *Global Cold Chain Capacity Report* was released. A difference in 2016 is that Mexico was included on the list of the fastest-growing markets. The CAGR of refrigerated warehouse capacity growth in Mexico, Turkey, and China was greater than 15% between 2014 and 2016 (Figure 7).

Another difference from the last GCCA Global Cold Storage Capacity Report was that India did not continue on the fastest short-term growth trajectory. The short-term growth rate in India slowed to a 4% compounded annual rate between 2014-2016.

Trends 2008-2016

Over the last 8 years, annualized growth was greater than 20% per year in Turkey, India, China, and Mexico. Figure 7 compares the short-term and long-term annualized growth rates for selected countries in order to distinguish between acceleration or deceleration of growth. In each country, the growth rates have been declining even as the smoothed growth rate over the long term history indicated positive market development.

Turkey was the fastest growing market over the last 8 years but its rate of capacity expansion has subsided recently to 17% between 2014 and 2016. The United States has likewise experienced a slowdown in the rate of expansion of refrigerated warehousing during the last two years. The CAGR for 2014-2016 in the United States was 2% while the 8-year annualized rate was 4%.

By contrast, developed countries have had modest annual growth rates in refrigerated warehouse space. Some European countries reported consolidation over the last few years so that total capacity of refrigerated warehousing has fallen (Figure 9).

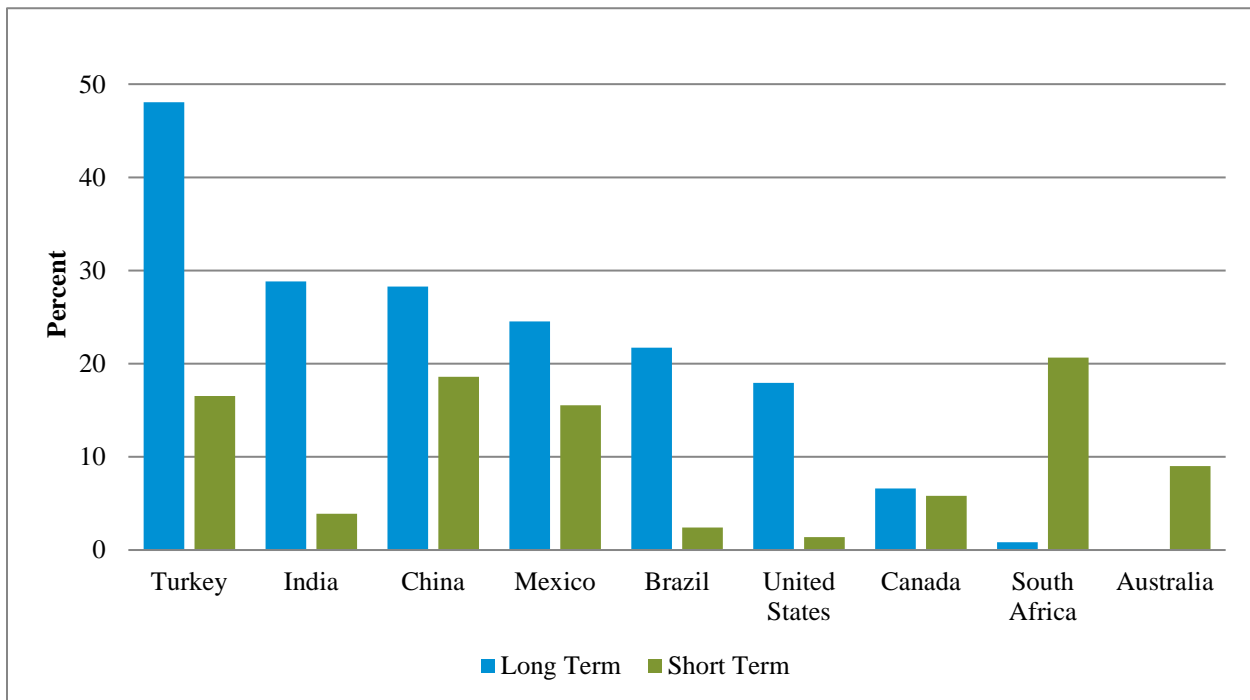
Longer term growth rates

In a few developing countries, cold storage capacity growth rates have been greater than 10% on an annual compound basis since 1998. India, China, Brazil and Turkey reported long-term growth at the fastest pace, compounded over the past 18 years (Table 3).

Table 3:
Estimated Annual Growth in Refrigerated Warehouse Capacity, Various Historical Periods through 2016.

Compound annual growth rate (%) 2008-2016		Compound annual growth rate (%) 1998-2016	
Turkey	48.1	Turkey	23.7
India	28.8	India	17.9
China	27.8	China	12.7
Mexico	21.7	Brazil	12.3
		United States	4.04
		Australia	1.96

Figure 7:
Compound annual growth rate (CAGR) of refrigerated warehouse capacity, by country, in short term (2014-2016) and long term (2008-2016).



Note: The column in solid color on the left is the CAGR for 2014-2016. The column on the right is the 8-year compounded rate (based on 2008-2016).

Figure 8:

Compound Annual Growth Rate in Refrigerated Warehouse Capacity, in % by Country, Annualized for 2008—2016.

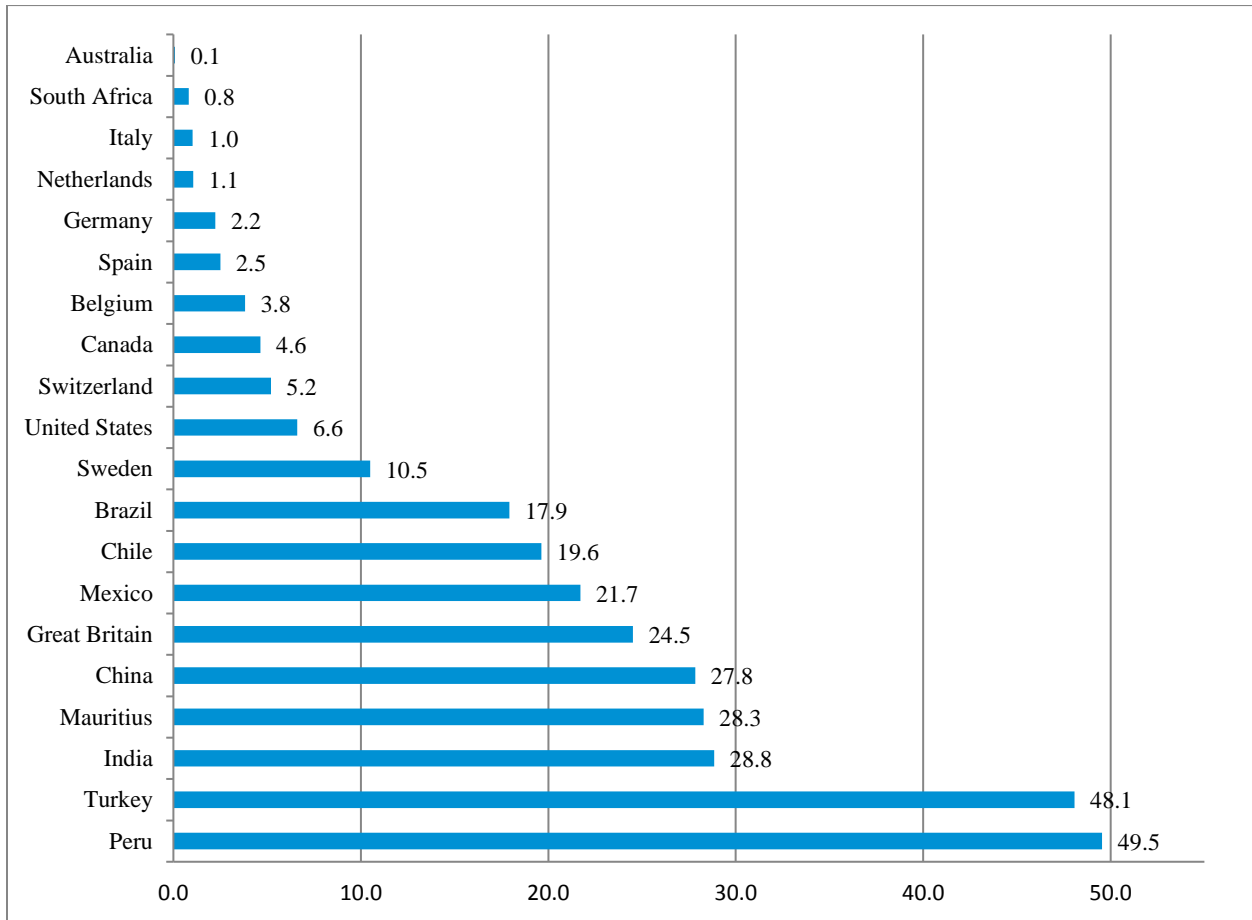
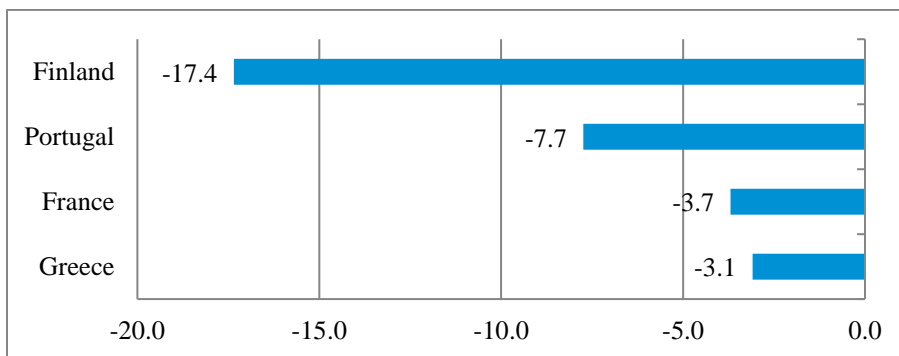


Figure 9:

Compound Annual Growth Rate (Capacity Reductions) in Refrigerated Warehouse Capacity, in % by Country, Annualized for 2008—2016.



Income Effects

The ultimate driver of demand for refrigerated warehousing in most countries is consumers' ability and willingness to purchase refrigerated or frozen foods. In a few countries that export foods, the refrigerated warehouse industry supports production and exports, and in those countries, the income of buyers overseas is also a factor in the expansion of capacity.

Statistical Model

There is not a simple linear relationship between consumers' income and demand for food. If a household has been in poverty, one can expect increases in total purchases of food as income grows because the consumers are meeting basic needs for food security. For very low income households, the additional food demand may be concentrated on staple goods, which are often shelf-stable and do not drive demand for refrigeration. For households transitioning into the middle class and higher income levels, the total quantity of food does not rise consistently with income because basic food needs have already been met and larger quantities are not necessary, yet there is a change in the composition of the diet. The middle-income consumers tend to purchase more of the higher value foods as their income grows. In these markets, one can expect the food in storage to increasingly include perishable meats, poultry, and dairy items, therefore boosting the need for cold storage.


A side-by-side comparison of warehouse capacity and the annualized rate of growth in consumer expenditure is in Table 4. Consumption expenditure is the variable that was used to represent household income. The personal consumption expenditure variable is preferable to a nation's GDP in that it focuses on households more than the macroeconomic indicator GDP. GDP includes aggregate investment and government spending, neither of which is directly relevant to household income.

Statistical modeling indicates that income is the leading driver of refrigerated warehouse market development per capita, the MDI. The results were reported on page 10. Similar statistical procedures were used to relate household consumption to the percentage growth rates in refrigerated warehouse capacity. Household income in European markets was stagnant or even declining in recent years, and growing moderately (between 2% and 5%) in the USA, Canada, and South Korea. The wide variation in nominal growth rates led to statistically insignificant results in the cross-sectional model of income growth against capacity growth.

Retail Trade Channels

The maturity of the supermarket retail trade in a country, relative to traditional wet markets or neighborhood stores, is indicated by the annualized growth rate of retail sales, per-capita, in modern food retail outlets (supermarkets and hypermarkets). The data (from Euromonitor Passport database) are shown in the far right column of Table 4.

Supermarket retail sales have been growing at the same pace or a bit more slowly than consumer income in many of the developing or emerging market countries, over the last 5 years (Table 4). There are exceptions where the expansion of supermarket retail outpaced consumers' income. The most promising markets for supermarket retail which also report refrigerated warehouse capacity were the Dominican Republic, Ecuador, Guatemala, Iran, and Kenya. Per capita supermarket sales exceeded \$200 per year in these countries (as of 2015). In addition, growth had been between 10% and 20% annually during the previous 5 years.



In contrast, there are countries in which supermarket sales were fast-growing but considerably less promising because of the low market shares of modern retail. For example, in Indonesia and Nigeria, the base level of per capita expenditure in supermarkets is so small (below \$100) that the percentage growth rate is less meaningful. India exhibited an even lower market share for supermarket retail. Growth rates in India in supermarket sales and consumer income were roughly equal, yet per capita supermarket sales were less than \$15 per year in 2015. This is further evidence that India remains a fragmented and traditional food retail system (as indicated in Miller 2016).

Several developed countries in Europe have experienced stagnating supermarket sales over the last 5 years. For example, the compound annual growth rate of supermarket retail sales was less than 1% per year in Denmark, Italy, and Switzerland. Supermarket retail sales contracted in Greece by 1.5%, annualized, since 2010.

Table 4:**Capacity of Refrigerated Warehouses and Selected Economic Indicators, by Country**

Country	Area under Refrigeration, Million m ³	Year of Capacity Report	Growth in Income (Cons. Expenditure, Nominal) CAGR 2010-2015	Growth in Modern Grocery Retail Sales, (Nominal) CAGR 2010-2015
Afghanistan	0.0181	2016	5.2%	-
Australia	6.04	2016	4.8%	3.1%
Austria	1.00	2014	2.7%	2.0%
Bangladesh	0.129	2014	12.5%	-
Belgium	2.70	2016	2.0%	1.4%
Brazil	16.83	2016	9.8%	8.8%
Canada	9.91	2016	3.8%	2.6%
Chile	3.69	2016	9.0%	8.4%
China	107	2016	12.8%	8.6%
Colombia	0.10	2014	7.6%	6.3%
Denmark	3.00	2014	2.2%	0.9%
Dominican Republic	0.024	2014	7.6%	11.9%
Ecuador	0.043	2016	6.9%	13.1%
Egypt	3.25	2014	16.5%	12.1%
El Salvador	0.02	2016	3.5%	-
Finland	1.00	2014	3.0%	2.0%
France	6.29	2016	1.3%	1.3%
Germany	16.0	2016	2.3%	1.5%
Great Britain	32.37	2016	3.9%	3.0%
Greece	0.7	2014	-3.8%	-1.5%
Guatemala	0.035	2014	7.7%	10.6%
India	141.13	2016	14.2%	15.3%
Indonesia	3.87	2016	11.2%	18.9%
Iran	14.00	2014	25.8%	38.5%
Ireland	3.80	2016	2.5%	1.9%
Italy	4.50	2014	0.5%	0.8%
Japan	32.65	2014	0.4%	2.4%
Kenya	0.022	2016	15.0%	19.8%
Kuwait	0.33	2016	7.2%	-
Libya	0.25	2014	3.8%	-
Mauritius	0.22	2016	6.4%	
Mexico	6.50	2016	7.1%	6.0%
---Continued on the next page.				

Table 4-Continued:

Capacity of Refrigerated Warehouses and Selected Economic Indicators, by Country

Country	Area under Refrigeration, Million m³	Year of Capacity Report	Growth in Income (Cons. Expenditure, Nominal) CAGR 2010-2015	Growth in Modern Grocery Retail Sales, (Nominal) CAGR 2010-2015
Morocco	1.70	2016	5.1%	6.4%
Namibia	0.15	2014	10.5%	-
Netherlands	13.7	2016	1.4%	1.9%
New Zealand	1.71	2014	3.6%	2.0%
Nigeria	0.04	2014	14.7%	23.1%
Oman	0.02	2014	-2.4%	-
Panama	0.14	2014	9.1%	-
Peru	2	2016	8.7%	11.0%
Portugal	0.42	2016	0.3%	1.12%
Romania	0.5	2016	5.2%	8.8%
Saudi Arabia	1.40	2014	8.7%	10.8%
South Africa	0.47	2016	8.5%	8.3%
South Korea	12.0	2016	3.6%	3.4%
Spain	10.0	2016	0.4%	1.4%
Sweden	2.0	2016	2.9%	2.8%
Switzerland	1.5	2016	1.0%	0.5%
Tunisia	1.31	2014	7.9%	9.6%
Turkey	9.24	2016	11.6%	13.7%
United States	118.07	2016	3.7%	2.3%
Uzbekistan	3.54	2016	26.9%	24.0%
Yemen	0.06	2014	4.2%	-

Sources: Capacity data are from GCCA survey and selected government reports. Data on income and retail are from the Euromonitor Passport database.

Note: - indicates not available.



Transportation Systems

While income and the closely associated food retail industries are measurable drivers of the ultimate demand for refrigerated warehousing, there are also supply-side constraints that should be considered. The operational feasibility of a warehouse is closely tied to transportation networks. Roads, bridges, and ports are important for service providers operating on a for-hire basis. The local transportation situation is naturally very complex and requires site-specific information.

Comparisons of transportation and infrastructure quality across countries are made, using national-level assessments provided by the World Bank and the World Economic Forum. The World Bank Logistic Performance Index (LPI) is based on six quantitative and qualitative elements:

1. Efficiency of customs and border management clearance,
2. Quality of trade and transport infrastructure,
3. Ease of arranging competitively priced shipments,
4. Competence and quality of logistics services—trucking, forwarding, and customs brokerage,
5. Ability to track and trace consignments, and
6. Frequency with which shipments reach consignees within scheduled or expected delivery times.

The highest-ranked countries according to the LPI are developed economies (Table 5). None of the emerging economies where refrigerated warehousing industries were expanding most rapidly appear on the top 20 of the World Bank LPI.

Within the developing world, several countries received noteworthy upgrades on the LPI. A country moving up in the global ranking is indicated by a negative number in Table 6. For example, in 2010, Rwanda was ranked 151 and in 2015 Rwanda moved to 73, an improvement of 78 levels on the ranking. The list of countries with the greatest improvements in transportation systems includes Namibia and Nigeria—two countries that reported on capacity of refrigerated warehouses to GCCA.

The World Economic Forum transportation quality index is obtained from inquiries of the business community. See table 7 for the country list. Similar to the World Bank LPI, the overall transportation quality index scores are highest for developed economies. The component indicators are:

1. Quality of roads,
2. Quality of railroad infrastructure,
3. Quality of port infrastructure,
4. Quality of air transport infrastructure,
5. Available Airline seats,
6. Quality of electricity supply,
7. Fixed telephone lines per capita, and
8. Mobile telephones subscriptions per capita.

Table 5:
Top 20 Countries Ranked by World Bank Logistics Performance Index for 2010-2015

Rank	Country	Rank	Country
1	Germany	11	Denmark
2	Singapore	12	Switzerland
3	Netherlands	13	Canada
4	Belgium	14	Norway
5	Great Britain	15	France
6	Sweden	16	Finland
7	Japan	17	Australia
8	Hong Kong, China	18	Ireland
9	United States	19	Austria
10	Luxembourg	20	Taiwan

Source: World Bank

Table 6:
Improvement in Country Ranking on World Bank Logistics Performance Index for the period 2010-2015, and Refrigerated Warehouse Market Development Index (MDI).

Country	Number of positions improved, 2010-2015	Country	Number of positions improved, 2010-2015
Rwanda	-78	Ukraine	-44
Nepal	-64	Angola	-40
Montenegro	-60	Fiji	-39
Burkina Faso	-59	Solomon Islands	-37
Namibia (MDI =0 .17)	-55	Pakistan	-35
Cambodia	-50	Guyana	-33
Maldives	-47	Liberia	-33
Algeria	-46	Nigeria (MDI =0.0)	-32
Sri Lanka	-44	Guinea-Bissau	-31
Jamaica	-.44	Ethiopia	-31

Note: A negative number indicates number of positions that the country moved up in the ranking)
 Source: World Bank. MDI is refrigerated warehousing per urban resident, cu meters.

Table 7:

Ranking and Index Value for Quality of Overall Infrastructure, Quality of Roads (2014-2015) and Refrigerated Warehousing MDI.

Country	Transport Overall		Roads	Refrig.	Country	Transport Overall		Roads	Refrig.
	Rank	Index	Index	MDI		Rank	Index	Index	MDI
Switzerland	1	6.61	6.00	0.25	Slovenia	34	5.07	4.90	
Hong Kong	2	6.47	6.04		Australia	35	5.06	4.75	0.28
United Arab Emirates	3	6.43	6.61		Ireland	36	5.05	5.27	
Finland	4	6.39	5.87	0.09	Sri Lanka	37	5.05	5.09	
Singapore	5	6.29	6.05		Czech Rep.	38	5.03	3.70	
Netherlands	6	6.26	6.14	0.96	Panama	39	5.01	4.74	0.05
Austria	7	6.21	6.27	0.17	Latvia	40	5.00	3.09	
Iceland	8	6.20	4.89		Hungary	41	4.99	4.25	
Japan	9	6.16	5.92	0.28	Namibia	42	4.98	5.2	0.17
France	10	6.05	6.17	0.11	Lithuania	43	4.92	4.94	
Germany	11	6.03	5.88	0.27	Croatia	44	4.91	5.62	
Portugal	12	6.01	6.34	0.06	Puerto Rico	45	4.91	5.91	
Spain	13	5.93	5.91	0.28	Malta	46	4.89	3.65	
Luxembourg	14	5.87	5.71		Azerbaijan	47	4.81	3.96	
Denmark	15	5.79	5.43	0.61	Jordan	48	4.79	4.14	
United States	16	5.76	5.69	0.44	Mauritius	49	4.75	4.80	
Belgium	17	5.76	5.25	0.25	Chile	50	4.74	5.12	0.23
Sweden	18	5.69	5.50	0.24	Seychelles	51	4.65	4.20	
Canada	19	5.65	5.34	0.34	Trinidad & Tob.	52	4.65	3.99	
Malaysia	20	5.63	5.59		Bhutan	53	4.63	4.31	
Bahrain	21	5.57	5.37		Georgia	54	4.63	4.03	
Barbados	22	5.56	5.06		Morocco	55	4.60	4.46	0.09
South Korea	23	5.49	5.60	0.28	Italy	56	4.59	4.26	0.09
Taiwan	24	5.46	5.89		Greece	57	4.58	4.32	0.10
Oman	25	5.44	6.01		El Salvador	58	4.57	4.64	0.01
Qatar	26	5.42	5.03		South Africa	59	4.49	4.93	0.01
Gr. Britain	27	5.35	5.18	0.62		60	4.46	3.74	
Norway	28	5.31	3.86		Armenia	61	4.42	3.71	
Saudi Arabia	29	5.24	5.27	0.06	Kazakhstan	62	4.42	2.98	
Cyprus	30	5.23	5.31		Israel	63	4.41	4.71	
Estonia	31	5.16	4.39		China	64	4.36	4.61	0.14
New Zealand	32	5.12	4.95		Kenya	65	4.35	4.24	0.00
Turkey	33	5.10	4.88	0.17	Laos	66	4.35		

Table 7, Continued:

Ranking and Index Value for Quality of Overall Infrastructure, Quality of Roads (2014-2015) and Refrigerated Warehousing MDI.

Country	Transport Overall		Roads	Refrig.		Country	Transport Overall		Roads	Refrig.
	Rank	Index	Index	MDI			Rank	Index	Index	MDI
Kuwait	67	4.32	4.63	0.08		Cape Verde	94	3.67	4.04	
Rwanda	68	4.26	4.68			Philippines	95	3.66	3.57	
Mexico	69	4.22	4.42	0.07		Kyrgyz Rep.	96	3.63	2.73	
Jamaica	70	4.21	3.66			Senegal	97	3.62	3.36	
Gambia	71	4.17	4.10			Lesotho	98	3.60	3.33	
Indonesia	72	4.17	3.93	0.03		Bolivia	99	3.60	3.35	
Slovak Rep.	73	4.17	3.69			Bulgaria	100	3.59	3.14	
Russia	74	4.13	2.72			Mali	101	3.59	3.35	
Ukraine	75	4.11	2.21			Algeria	102	3.59	3.13	
Thailand	76	4.07	4.47			Costa Rica	103	3.55	2.83	
Cote d'Ivoire	77	4.03	3.91			Uganda	104	3.51	3.20	
Swaziland	78	4.00	4.88			Cambodia	109	3.37	3.35	
Poland	79	3.99	3.55			Ghana	110	3.36	3.73	
Uruguay	80	3.99	3.53			Serbia	111	3.35	2.93	
Suriname	81	3.96	3.95			Vietnam	112	3.33	3.20	
Iran	82	3.93	4.09	0.25		Pakistan	113	3.32	3.81	
Tunisia	83	3.92	3.69	0.18		Nicaragua	114	3.31	3.55	0.00
Macedonia	84	3.91	3.38			Ethiopia	115	3.21	3.79	
Guyana	85	3.82	3.22			Cameroon	116	3.16	2.90	
Moldova	86	3.81	2.14			Tanzania	117	3.15	3.03	
Albania	87	3.80	3.94			Malawi	118	3.13	3.30	
Romania	88	3.79	2.75			Mongolia	119	3.11	2.58	
Botswana	89	3.77	3.98			Brazil	120	3.11	2.75	0.10
India	90	3.75	3.79	0.34		Zimbabwe	121	3.09	3.28	
Montenegro	91	3.73	3.32			Madagascar	122	3.09	2.60	
Zambia	92	3.68	3.58			Argentina	123	3.00	3.04	
Dominican Rep.	93	3.67	4.40	0.00		Mozambique	124	2.96	2.13	

Table 7, Continued:

Ranking and Index Value for Quality of Overall Infrastructure, Quality of Roads (2014-2015) and Refrigerated Warehousing MDI.

Country	Transport Overall		Roads	Refrig.		Country	Transport Overall		Roads	Refrig.
	Rank	Index	Index	MDI			Rank	Index	Index	MDI
Egypt	125	2.94	2.87	0.09		Venezuela	135	2.6	2.64	
Nepal	126	2.93	2.9			Yemen	136	2.46	2.46	
Sierra Leone	127	2.9	3.04			Burkina Faso	137	2.37	2.46	
Gabon	128	2.88	2.43			Myanmar	138	2.34	2.44	
Timor-Leste	129	2.87	1.92			Chad	139	2.28	2.64	
Bangladesh	130	2.82	2.88	0.00		Lebanon	140	2.28	2.77	
Burundi	131	2.75	3.24			Angola	141	2.25	2.26	
Paraguay	132	2.68	2.45			Haiti	142	2.18	2.37	
Nigeria	133	2.67	2.68	0.00		Guinea	143	2.1	1.94	
Mauritania	134	2.64	2.31			Libya	144	1.85	2.11	

Source: World Economic Forum. MDI is from GCCA sources.

Selected Country Profiles

China

As the second-largest economy in the world, China was also a major player in the cold storage industry, with refrigerated warehouse capacity of 107 million cubic meters. This was a 21% increase since 2014. Investments in refrigerated warehouses, refrigerated trucks, and highways are underway and planned by several companies. The new operations are a mix of public, for-hire facilities and privately operated warehouses to serve supermarket retail channels and the emerging Internet shopping channel.

According to the Journal of Commerce, the Chinese cold-chain logistics industry was expected to grow 25 percent annually through 2017. Some of these investments are oriented toward the support of handling and distribution of production of fresh produce. Reports indicated that 15 agricultural cold-chain parks are planned in the next five years.

Investments in large-scale refrigerated warehouses are planned by a public warehouse provider to serve food processors' needs on an outsourced basis. These investment plans are related to the shift toward more use of supermarket and hypermarket retail formats in China. In 2015, modern grocery retailers represented 39% of total retail volume of fresh food sales in China (Euromonitor). The CAGR of retail supermarket sales in China was 8.6% annually between 2010 and 2015.

The Internet shopping channel for food retail was booming last year, reaching 2% market share for fresh foods (Euromonitor). The leading companies have been positioning for access to the distribution assets that will be needed if the growth in online food sales persists. Alibaba was increasing investments in the logistics industry, planning to spend \$16 billion for distribution capability to support its strategy to sell more perishable foods. It remains to be seen the scale and scope of distribution systems that will be driven by the online food retail channel.

India

According to the GCCA database, India has the largest total capacity of refrigerated warehousing in the world when ranked by country. In 2016, India's reported capacity was 141 million cubic meters an 8% increase over the 130 million m³ in 2014. Although refrigeration capacity was expanding, a gap of 14 million m³ (3.28 million metric tons) relative to the need remained, according to "The Times of India." The necessary investments include pack-houses, reefer vehicles and ripening chambers in different parts of the country to connect the farm production sector with retail outlets.

According to Euromonitor, the government of India planned to build 50 cold storage facilities, most of them in food parks that also provided facilities for production, processing, collection and transportation. Five of these food parks were already operating in December 2015, and a total of 42 food parks were scheduled for construction by 2020.

In 2015, modern grocery retailers had a low market share in India. Modern store formats accounted for only 11 percent of total retail food volume in India, a scant increase of 0.8 percentage points since 2010.

India presents a unique situation among the countries studied in this report. While its income per capita was growing, modern retail formats have very low presence in the share of food sales and transportation quality is not as high as in other large emerging markets. Hence the growth in refrigerated warehousing in India is not well explained by the driving forces that are generally predictive of market penetration of the cold chain. There are indications of government support for refrigerated warehousing and related

infrastructure but, according to GCCA sources, less activity from the private sector compared with other countries around the world.

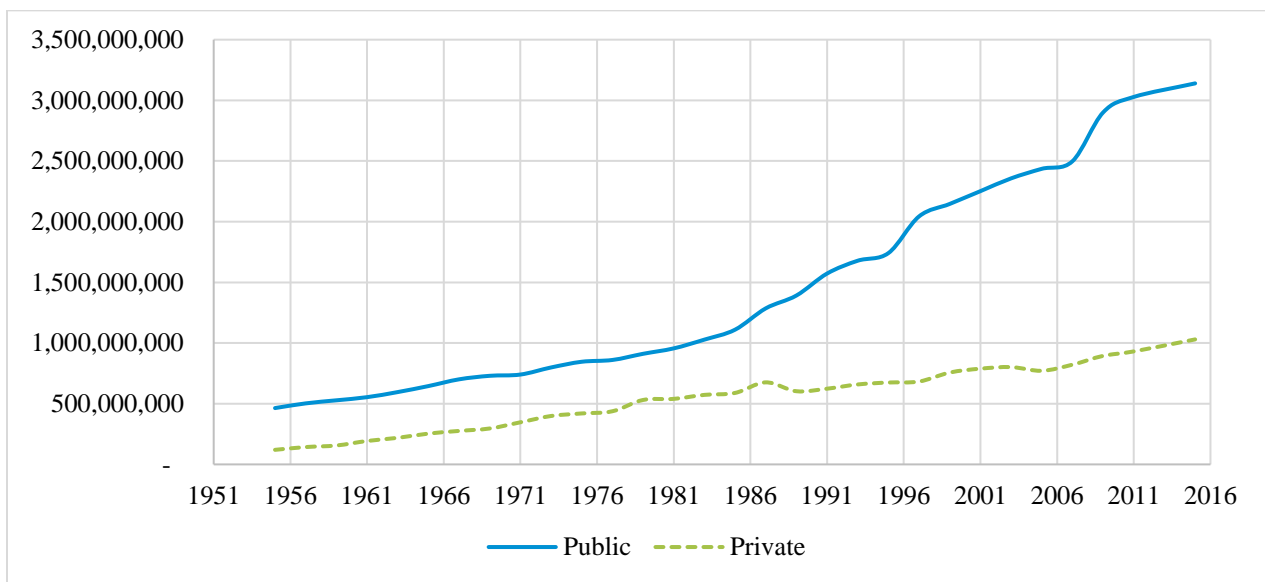
United States

The most recent biennial national survey of refrigerated warehouses in the United States was October 1, 2015 (U.S. Department of Agriculture). The survey indicated that gross capacity rose by 3% between 2013 and 2015. The five states with the largest warehouse capacity were: California, Florida, Texas, Georgia, and Pennsylvania.

Along with the growth in gross capacity, the number of refrigerated warehouses declined, which indicates consolidation of the industry into larger facilities (Table 8). Public warehouse numbers fell by 39 facilities and private warehouse numbers fell by 28 facilities. The change in the size distribution of U.S. refrigerated warehouses is illustrated in Figure 12. The three smallest size categories (below 2.5 million cubic feet) declined. There were modest increases in the numbers of warehouses that were in the size classes of 2.5 million cubic feet or larger.

The growth in public refrigerated storage (third-party for hire) between 2013 and 2015 was 1.9 million cubic meters in the USA. Growth in the public warehouse industry market size exceeded the growth in private cold storage (1.6 million cubic meters) that the U.S. government reported between 2013 and 2015. Public cold storage capacity had a 75% share of the market, unchanged from 2011 and 2013 (Figure 11).

Figure 11:
Public and Private Refrigerated Warehouse Capacity in USA, 1955-2015, in Cubic Feet



Source: United States Department of Agriculture based on survey conducted October 1, 2015.

Table 8:

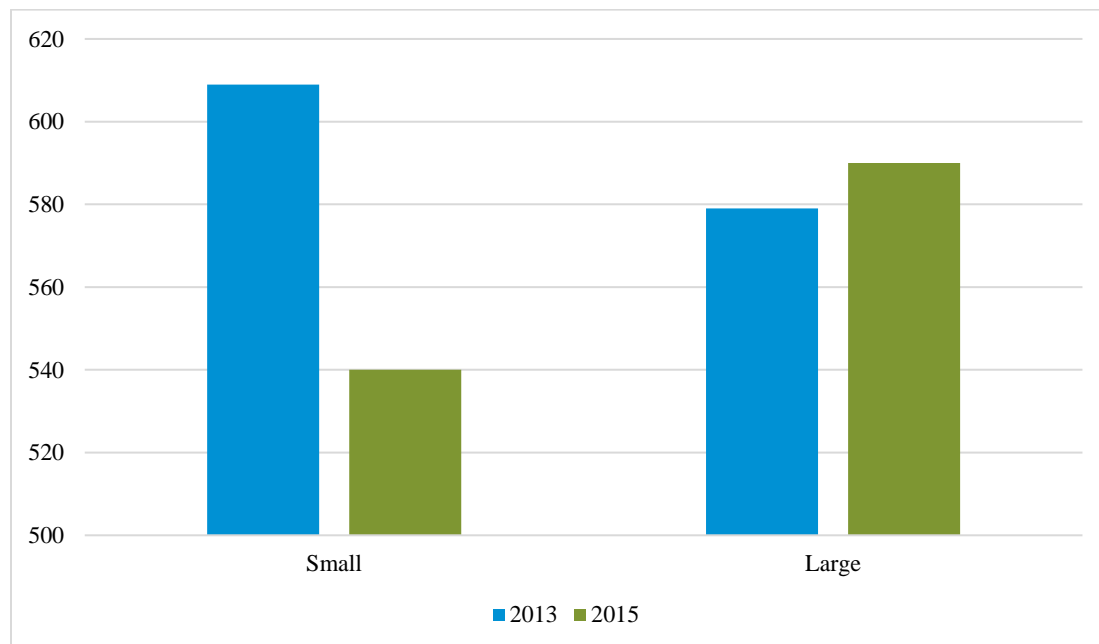
Distribution of United States Refrigerated Warehouses by Size Class, 2014 and 2015

Size class in Cubic Feet	2013	2015	Change in numbers	Percent change
0-499,999	432	374	-58	-13.4%
500,000-999,999	177	166	-11	-6.2%
1,000,000-2,499,999	309	300	-9	-2.9%
2,500,000-4,999,999	319	320	1	0.3%
5,000,000 and over	260	270	10	3.8%
All sizes	1,497	1,430	-67	-4.5%

Source: United States Department of Agriculture based on survey conducted October 1, 2015.

Figure 12:

Change in Size Distribution of Refrigerated Warehouse Numbers in the United States, 2013-2015



Source: United States Department of Agriculture based on survey conducted October 1, 2015.

Table 9:**Capacity and Size of Refrigerated Warehouses in the United States, by Public/Private Business, 2005-2015 in million cubic feet**

	2005	2007	2009	2011	2013	2015
Public Number of Facilities	821	792	839	825	802	763
Public Freezer Space	2,051	2,093	2,441	2,562	2,632	2,643
Public Total Space	2,436	2,498	2,901	3,028	3,077	3,138
Public Average Facility Size	2.97	3.15	3.46	3.67	3.84	4.11
Freezer Share of Public	84%	84%	84%	85%	86%	84%
Private Number of Facilities	681	709	739	703	695	667
Private Freezer Space	440	447	486	508	512	553
Private Total Space	772	822	894	931	978	1,030
Private Average Facility Size	1.13	1.16	1.21	1.32	1.41	1.54
Freezer Share of Private	57%	54%	54%	55%	52%	54%
Total Number of Facilities	1,502	1,501	1,578	1,528	1,497	1,430
Total Gross Space	3,207	3,320	3,795	3,959	4,055	4,169

Source: United States Department of Agriculture based on survey conducted October 1, 2015



Conclusions

The refrigerated warehousing industries worldwide grew at a 4.2% annualized rate of growth between 2014 and 2016 to reach total capacity of 600 million cubic meters. China and India were the largest emerging markets in absolute capacity of the refrigerated warehouse industry.

On a per-capita basis, globally, there was an average of 0.2 cubic meters of refrigerated warehouse space per urban resident. Refrigerated warehouse capacity was high, relative to population, in the developed world. During the last two years, the industry declined in some European countries. In most of the emerging markets, refrigerated warehouse capacity grew more rapidly than the growing urban population. There were two important exceptions, China and Brazil, where per-capita size of the refrigerated warehouse industry only marginally increased since 2014.

The expansion of large-scale supermarket and hypermarket retail store formats led the growth of refrigerated warehousing in many developing countries. In terms of statistical relationships, both supermarkets and refrigerated warehousing rose along with personal income of the population.

Transportation quality indicators point out the markets where household income remained relatively low but the infrastructure improvements might indicate market opportunities. Many of the countries that improved the most in logistics were in sub-Saharan Africa, according to the World Bank index. Few sub-Saharan African countries scored above the mid-point of the World Economic Forum's roadway quality index, only Swaziland, Botswana, and Zambia.

In the United States, an additional 1.6 million cubic meters of capacity were added to the public refrigerated warehouse industry since 2014. Public cold storage capacity held 75% share of the market. Consolidation of the U.S. industry into fewer larger warehouses was a notable trend in the industry since 2014.

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