Designing the Cold Chain for Safety & Sustainability

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The cold chain is characterized by a series of hand-offs where technology is helping to ensure that those hand-offs are both safe and efficient. Global cold chain integrity is becoming an increasingly vital component of a sustainable, safe and secure food supply chain.
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macro backdrop
long-term, structural market shift in food industry is creating opportunities for outsourced services such as cold chain logistics providers...

The food industry has gone through, and is currently going through, many changes

150 YEARS OF EVOLUTION IN THE FOOD CHAIN CREATED...
- More efficient distribution
- More processing
- Lower prices
- Higher degree of food safety
- Increase in demand of outsourced services
- Global food supply chain

...BUT RECENT MACRO TRENDS ARE STRUCTURALLY DIVERGENT FROM THE PAST AND ARE CHARACTERIZED BY INCREASING:

UNCERTAINTY
CONSUMER DEMANDS are continuously and rapidly evolving and require processing, handling and distribution techniques that differ from the past

COMPLEXITY
SUPPLY CHAIN has become increasingly complex and global, which increases the risk of food safety incidents and for waste

VELOCITY
PACE OF CHANGE is faster and increasing and global population growth will require new approaches and doing more with less
agrifood is considered to be one of the least digitized & innovative industries...but that is changing

Food & agriculture is relatively inefficient when compared to other industries, and the pace of innovation has not kept up with other industries. The sector receives less than 2% of venture capital investment dollars but represents 10% of global GDP. Despite historical underinvestment trends, the need for new approaches and innovation in the $7.5T+ food system is greater than ever as the food supply chain faces growing safety, sustainability and security challenges.

EMERGING MEGATREND: FOOD AS MEDICINE

Food is inextricably linked to health but our healthcare system does not treat it that way.

SUSTAINABILITY DISCUSSIONS ON FOOD SHOULD INCORPORATE SUSTAINABILITY FROM BOTH ECONOMIC AND ENVIRONMENTAL PERSPECTIVES

POOR DIET IS A LEADING CAUSE OF DEATH

- Poor diet is a contributor to 4 of the top 6 leading causes of death, second only to tobacco.
- Over 50% of adult Americans are considered overweight or obese.
- There are social and inclusion issues as well as there is an inverse correlation between energy density and direct food costs; indirect costs are not adequately priced into food costs today.

700k deaths each year from heart disease, stroke, obesity, diabetes, certain cancers and brain health are largely influenced by what we eat.

FOCUS ON DRIVERS OF POOR HEALTH

- As costs continue to rise, policymakers have typically focused on reducing healthcare delivery costs to control the growth in healthcare expenditures.
- Shift focus to food crisis to help control chronic disease and illnesses by impacting what people eat to improve health of public by addressing chronic diet-related health problems.

50% of Americans have at least one chronic condition.

86% of national health expenditures is for patients with at least one chronic condition.

$3.3T in national health expenditures, is up 5% y-o-y.

Source: CDC, National Center for Health Statistics, CMS National Health Expenditure Data.
2

state of the cold chain today
cold chain systems have significantly improved public health by maintaining the integrity of food throughout the supply chain…

As populations rapidly urbanized in the industrialized West in the early 20th century, refrigeration indirectly improved dietary habits by enabling the safe movement of fresh meats and other fresh food perishables to urban populations.

WELL DESIGNED COLD CHAIN SYSTEMS SAFELY MOVE TEMPERATURE-SENSITIVE FOOD PRODUCTS IN A WAY THAT:

REDUCES WASTE
by preserving and extending shelf life to keep food edible

MAINTAINS THE QUALITY & INTEGRITY OF FOOD PRODUCTS
to slow bacterial growth and prevent foodborne illness by protecting products from fluctuations in temperature, moisture and humidity

LIMITS OPPORTUNITIES FOR CONTAMINATION
through proper handling procedures

THE MOST IMPORTANT INVENTION IN FOOD?

▪ Royal Society reviewed over 100 inventions in food across four criteria: accessibility, productivity, aesthetic and health
▪ Refrigeration was voted as the most important with pasteurization / sterilization coming in second

...and the importance of maintaining cold chain integrity continues to increase globally

Convergence of forces has rapidly increased the need for specialized refrigeration as global demand for cold chain storage is forecasted to grow at a 15% CAGR through 2025 to $450B

**MAJOR COLD CHAIN DEMAND DRIVERS**

**CONSUMER DEMANDS**
for fresher, healthier & ethnically diverse foods

- **>5%** growth in cold chain protected foods  vs.  **1-2%** growth in center store food products

**EMERGING COUNTRIES**
are investing billions to increase cold chain capacity, most notably China & India

- **35%+** growth in cold chain capacity through 2022  vs.  **40%** subsidies to incentivize development of cold chain infrastructure

**DEMANDS FOR CONVENIENCE & VARIETY**
is changing way food is stored & distributed

- **25%** growth in e-commerce food sales  vs.  **-0.3%** decline in traditional supermarket sales

**GLOBAL FLOWS OF PERISHABLE FOOD**
are increasing, driven by trade policies and Panama Canal widening project

- **3.0x** increase in value of food products imported into the US since 2000  vs.  **75%** of food products imported are considered temperature-sensitive that require cold storage

**REQUIRES STRUCTURAL ADJUSTMENTS ACROSS FOOD SUPPLY CHAIN AND COLD CHAIN INDUSTRY MUST ADAPT QUICKLY TO MEET THESE DEMANDS SAFELY AND SUSTAINABLY**

1 | DEMAND DRIVER CASE STUDY

meat & poultry stocks in US cold storage are at an all-time high, exceeding 2.5bn pounds...

Record year of meat production and weakening international demand as a result of tariffs and trade disputes have led to record stockpiles of meat in cold-storage warehouses, up 8% year-over-year.

**U.S. MEAT & POULTRY COLD STORAGE STOCKS** *(in pounds)*

Demand Driver Case Study

and cheese stocks in US cold storage are also at an all-time high, exceeding 1.3bn pounds

Domestic cheese stockpile has increased 16% since the federal cheese buy-up in 2016 as milk production has significantly increased beyond weakening domestic consumer demand for dairy beverages and softening dairy trade exports

U.S. CHEESE COLD STORAGE STOCKS (in pounds)

these changing demand trends have upstream and downstream implications for food safety and sustainability

The increase in short and long-term cold storage stocks across all food commodity types is challenging current capacity utilizations and is increasing the overall carbon footprint of food chain

CHALLENGES FACING THE COLD CHAIN WITH INCREASING DEMAND

COLD STORAGE CAPACITY UTILIZATION
- Industry is considered to be at fully capacity
- Warehouses typically specialize around a commodity group to ensure food safety

>90% capacity utilization rates in markets located next to ports and cities

INEFFICIENT, AGING INFRASTRUCTURE
- Lack of quality inventory in major port markets with old, energy inefficient buildings
- Vacancy rates <3% in Port of NY-NJ

53 years is average age of Port NY-NJ warehouses largest share of refrigerated container market in US

ENERGY USE & HEAT INFILTRATION
- Refrigeration and ventilation systems require high power consumption to keep food safe
- Heat generation and infiltration from receiving, handling and moving product

~20% of total electric energy in food industry is consumed by cold storage warehouses

WASTE & POTENTIAL FOR INTERUPTION
- Increases risk for food waste if commodity becomes unprofitable to store
- Decrease in the net energy contribution for food products as amount of time in storage increases

interruption in cold chain systems impacts the safety and sustainability of the food chain…

Each year globally, 1.6B tons of food worth an estimated $1.2T is lost in the food chain, which is estimated to grow to 2.1B tons wasted worth $1.5T by 2030

<table>
<thead>
<tr>
<th>Stage</th>
<th>Waste (in million tons)</th>
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<tbody>
<tr>
<td>Production</td>
<td>500</td>
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<tr>
<td>Handling &amp; Storage</td>
<td>350</td>
</tr>
<tr>
<td>Consumption</td>
<td>340</td>
</tr>
<tr>
<td>Distribution &amp; Retail</td>
<td>200</td>
</tr>
<tr>
<td>Processing &amp; Packaging</td>
<td>160</td>
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</tbody>
</table>

WASTE IS MOST PRONOUNCED AT THE BEGINNING AND END OF THE VALUE CHAIN…

- **Production**: 500 million tons
- **Handling & Storage**: 350 million tons
- **Consumption**: 340 million tons
- **Distribution & Retail**: 200 million tons
- **Processing & Packaging**: 160 million tons

22% of food waste globally is driven by inadequate cold chain infrastructure

...BUT THE OCCURRENCE OF FOOD WASTE IS DIFFERENT BETWEEN MARKETS:

**DEVELOPED MARKETS**
- Consumption & retail
- Lack of awareness, education & information to make informed decisions

**DEVELOPING MARKETS**
- Production, handling & storage
- Inadequate infrastructure and procedures in post-harvest handling & storage

Up to 50% of developing countries’ perishable food supply is lost in post-harvest handling and storage, particularly in Africa and Asia

Source:
...and these food safety and sustainability issues are expected to be exacerbated in the future.

Regions with largest population growth and shifts in dietary preferences from an emerging middle class are also the regions currently with inadequate and inefficient cold chain infrastructure.

**MAJOR DRIVERS OF FOOD WASTE IN THE SUPPLY AND COLD CHAIN...**

**INFRASTRUCTURE**
- Infrastructure non-existent in many emerging markets located in high-risk climate areas
- Strong correlation of country’s cold chain capacity to country’s WEF Transport Index’s transportation score

**EFFICIENCY**
- Inefficient hand-offs and supply and demand imbalances caused by weak collaboration
- Insufficient regulatory and legal environment and/or low state capacity

**...REPRESENT A $270B OPPORTUNITY TO REDUCE FOOD WASTE**

<table>
<thead>
<tr>
<th>Category</th>
<th>Estimate in billions</th>
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<tbody>
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<td>Awareness</td>
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<tr>
<td>Supply Chain Infrastructure</td>
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</tr>
<tr>
<td>Supply Chain Efficiency</td>
<td>$120</td>
</tr>
<tr>
<td>Policy</td>
<td>$110</td>
</tr>
<tr>
<td>Collaboration</td>
<td>$60</td>
</tr>
</tbody>
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**PER CAPITA COLD STORAGE CAPACITY**

- **Japan** 0.38
- **US** 0.35
- **Great Britain** 0.29
- **India** 0.10
- **Brazil** 0.08
- **China** 0.06

75% less cold storage capacity on a per capita basis.

conventional approaches to sustainability in the cold chain have been focused on optimizing the cold chain as a specific stage and process

Cold chain service providers are increasingly adopting sustainable solutions to minimize the carbon footprint of their operations, which are currently focused on maximizing energy efficiency

CURRENT SUSTAINABILITY TRENDS

WAREHOUSE SPECIALIZATION

▪ Specialization around a commodity or commodity category
  ○ Limits truck stops as end-customers can pick up pallets from multiple vendors
  ○ Importers / exporters can easily trade commodities to meet customer demand

WAREHOUSE INFRASTRUCTURE & EFFICIENCY

▪ Trends towards taller warehouses to increase scale and capacity
  ▪ Energy consumption on a cubic foot decreases with increasing volume in non-linear relationship
▪ Upgrade insulation, roof, refrigeration equipment and lighting to reduce heat inputs and infiltration
▪ Position warehouse docks away from heat sources with automated insulated doors between loading dock chambers and warehouse
▪ Automate inventory handling and management and reduce truck idling times
▪ Optimize network design by locating warehouses in strategic areas – next to customers, ports, transportation networks or cities

TRANSPARENCY

▪ Use of sensors for monitoring cold chain integrity and energy efficiency (FSMA requires increased track and trace documentation procedures)

30-40% reduction energy costs through these strategies
3

a new approach for tomorrow
Designing the cold chain for safety and sustainability should be focused on a more holistic systems approach

Designing a cold chain that ensures the long-term security, safety and economic and environmental sustainability of the food supply chain requires a more holistic systems approach that optimizes the entire food chain.

**THINK OF A SYSTEM LESS OF A THING AND MORE OF A WAY OF DOING THINGS TO CREATE VALUE**

**SYSTEMS APPROACH TO COLD CHAIN OPTIMIZES NET VALUE**

- Availability of low-cost energy powered by fossil fuels has sustained a less efficient cold chain that consumes more energy than it supplies as nutritional value of end-food product.
- While this aforementioned approach works in a low-energy cost, resource rich environment, it is likely to break in the future as energy costs and resource constraints increase.
- A systems approach integrates, balances and manages the economic, environmental and social inputs and outputs of cold chain operations to maximize net nutritional value.

**FOCUS ON COLD CHAIN DEVELOPMENT**

- Development of the cold chain is relatively new from a policy perspective and should be incorporated into food security strategies to prepare for global demographic shifts.
- As food supply becomes increasingly global, create cold conditions early in value chain by supporting investment in emerging countries.

*60% of world’s population live in developing countries by 2030.*

*4.9B people in global middle class by 2030, up from 1.8B.*
shift worldview to new global governance framework that redesigns our food systems to ensure global public health

Requires a more integrated and collaborative approach that empowers science to help policymakers and business leaders take action towards a more desired future

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<tr>
<th>FROM</th>
<th>TO</th>
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<tbody>
<tr>
<td>PROCESS OPTIMIZATION</td>
<td>HOLISTIC ECOSYSTEM APPROACH</td>
</tr>
<tr>
<td>RESOURCE-INTENSIVE CONSUMPTION</td>
<td>RESOURCE-EFFICIENT CONSUMPTION</td>
</tr>
<tr>
<td>LOW CONNECTIVITY &amp; SILOS</td>
<td>HIGH CONNECTIVITY &amp; COLLABORATION</td>
</tr>
<tr>
<td>CLOSED INNOVATION</td>
<td>OPEN-SOURCE INNOVATION</td>
</tr>
<tr>
<td>REACTIONARY</td>
<td>PROACTIVE</td>
</tr>
<tr>
<td>SHORT-TERM DECISION MAKING</td>
<td>LONG-TERM PLANNING</td>
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to help shift towards a systems-driven approach, scenario planning can broaden our perspective by illustrating future risks & opportunities

As the world becomes increasingly inter-connected, decisions that are made today have long-term impacts. Scenarios can make leaders alert to potential future possibilities, both desirable and undesirable, to make informed strategic decisions towards a more desired future

**CHALLENGE ASSUMPTIONS**
by leveraging divergent thinking

**MAKE UNLIKELY CONNECTIONS**

**TAKE INFORMED RISKS**

**BUILD ON IDEAS TO MAKE BETTER IDEAS**
by looking at things in new ways

**TRAVEL TO EDGE OF SYSTEM & MOST FRAGILE AREAS**
to look for emerging trends that are precursors to change and innovation
a scenario analysis on the future of the food chain highlights the urgency of a systems approach

START WITH A STEP
employ stepping-stone initiatives that incrementally lead towards a more holistic systems in the future

CASE STUDY
IN THE CONTEXT OF THE COLD CHAIN, WE CAN MOVE TOWARDS A MORE DESIRED FUTURE STATE BY IDENTIFYING A DRIVER OF WASTE WHICH ULTIMATELY REPRESENTS A POINT OF WEAKNESS IN THE SYSTEM

Look beyond company walls to understand how the entire system can be made more efficient, resilient and sustainable
CASE STUDY

global flows of low moisture foods to the US are increasing...

Changing consumer demand, the globalization of the food supply chain and the Panama Canal widening project have increased the imports of nuts, dried fruit, ancient grains, seeds and legumes from South America, Asia, Africa and the Middle East to the US.

A GLOBAL, BOOMING NETWORK OF LOW MOISTURE FOODS

Source: Refrig-IT management and Tilia.
tilia holdings | ifsh: food waste and sustainability symposium
CASE STUDY

…and since 2000, US imports of tree nuts have increased by a factor of 2.5x

U.S. IMPORTS OF TREE NUTS (in million pounds)

Source: USDA, Tree Nuts and Fruit Yearbook Tables, 2016.
CASE STUDY

75% of the imported nuts and seeds consumed in the US pass through Port of NY-NJ

How are our customers’ needs evolving? Where are the points of waste?

LOW MOISTURE FOODS SAMPLE VALUE CHAIN: TREE NUTS

Emerging Markets
- Inputs Farmer
- Processing Roasting - Coating - Crushing
- Exporters Importers Traders
- Global Transportation to US

US Markets
- Customs Cold Storage
- Sterilization for DTC Consumption
- Domestic Processors
- Food Manufacturers Packaging
- Retail: Raw Ingredient Finished

Source: Refrig-IT management and Tilia.
**CASE STUDY**

**75% of imported nuts, seeds and dried fruits consumed in the US pass through Port of NY-NJ**

How are our customers’ needs evolving? Where are the points of waste?

**PORT OF NY-NJ: IMPORTED TREE NUTS**

**DEMAND DRIVERS**
- ~15% of imported nuts are consumed raw, a percentage that is increasing
- Food safety is an increasing concern as these raw nut products have unique sterilization needs as they are not roasted
  - Kept in frozen storage for 30-days to kill insects
  - New non-thermal pathogen processes and sterilization technologies are emerging to keep food safe without impacting nutrition, sensory or shelf-life characteristics while maintaining organic certification

**WASTE DRIVERS**
- Products are handled in and out of cold storage facilities near port to and from sterilization companies, which increases overall cost of product storage as trucking cost have increased
  - Increased transportation and handling also increases risk for adverse quality event
- Inadequate, inefficient infrastructure in Port of NY-NJ
- Pre-2007 heavy duty trucks were permitted to emit 10x as much PM2.5 as newer truck engine models


tilia holdings | ifsh: food waste and sustainability symposium

90% of port cargo is transported by truck

5.4M annual truck calls to port terminals & warehouses

99% of truck visits are diesel engines

54% of those trucks have engine models older than 2007
CASE STUDY

Collaboration with IFSH

TILIA’S PARTNERSHIP WITH IFSH ON FOOD SAFETY IN LOW MOISTURE FOODS

BACKGROUND

▪ Refrig-IT is the market leading provider of cold chain warehousing and supply chain services to customers throughout the imported nut and dried fruit value chain

▪ Investing in a Newark cold warehouse expansion project to add 135,000 square feet of mixed-use cold storage to accommodate increased demand

▪ In conjunction with new facility expansion, the company is also investing in non-thermal sterilization technology for pathogen control so products can be sterilized without leaving the warehouse

  ▪ As trucking costs have increased, customers have become more interested in Refrig-IT performing these services

ELIMINATING A WASTE DRIVER THROUGH COLLABORATION

▪ Keeping sterilization services down value chain is important to limit waste

▪ To meet changing consumer demand both safely and sustainably, Refrig-IT needed a partner to help solve these emerging, complex challenges

▪ Refrig-IT has partnered with IFSH Low Moisture Food Safety Task Force to limit food safety issues associated with low moisture foods by refining and setting standards through scientific research for validating preventative controls

Source: FTR Transportation Intelligence.
conclusion

Adopting a systems mindset provides an insight as to how leaders, policymakers and scientists can work together through multi-stakeholder collaboration to redesign the global food chain

**HOW MIGHT WE SAFELY, SUSTAINABLY AND NUTRITIOUSLY FEED 8.5 BILLION PEOPLE BY 2030?**

**Adopt a systems approach**
to look beyond company walls to ensure our food chain is resilient enough to survive high energy cost, resource scarce future

**Leverage scenario planning**
to make informed, long-term strategic decisions in an uncertain and complex macro-environment that are economically and environmentally sustainable

**Start with a step**
to design a more desirable future by identifying weaknesses in a particular value system

**Cognitively span boundaries through interdisciplinary depth**
through collaborations and partnerships
about us

ABOUT US
Tilia is a private investment firm focused exclusively on building distinctive companies that provide outsourced, technical services across the global food supply chain

our purpose
Stewards of businesses that make the food chain safe, nutritious and sustainable

our approach
Stewardship. Approach each investment as a steward and employ a set of core principles to improve capital across four key dimensions of capital: brand, human, social and financial

Focus. Solely focused on serving the fragmented and expanding global food economy

Parity. Integrated team with operating and financial expertise, a proven investment track record and deep domain knowledge and expertise in operations, strategy, private equity and governance

our principles
Culture. We are a mission-driven organization that believes interdisciplinary expertise and depth

Collaboration. Our business is built on long-term relationships established with trust and integrity

Creativity. We invest in innovation to underwrite sustainable growth

Counting. We set performance improvement goals and consistently measure our progress to hold each mutual accountable