Ximena M. Cordova, Ph.D.

Special thanks to Carla Tejada and Elizabeth Romero

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- **UNIVERSIDAD SAN FRANCISCO DE QUITO**
  - Ph.D in Industrial Engineering (1994) WSU
  - MSc in Quality Management and Productivity UIA
  - MSc in Actuarial Science UIA
  - Matematica EPN
- Currently: Dean of Engineering of the School of Science and Engineering
- Visiting professor at MIT
- Linnaeus – Palme, Sweden recipient
- Research interests:
  - Sustainability of Supply Chain in emergent markets
  - Ergonomics – The need for anthropometry to design work stations
- Special thanks to USFQ for the time provided to do research and specially to my research assistants Carla Tejada and most recently Elizabeth Romero
Distribution systems for the Textile industry

An Overview of the Logistics Characterization of the Textile Industry in Ecuador
Agenda

• Introduction
• Textile industry
  – Latin America
  – Ecuador
• Case Studies presentation
• Sustainability
  – NTM Methodology
• Conclusions and Further Studies
Supply Networks

• Supply chain networks have been present in our daily life since the beginning of the industrialization period
  – management of logistics became very important in order to be more efficient.
Supply Networks

Definition of supply chain, given by Harland and Knight (2001).

• They identify a supply chain as comprising of actors, resources and activities, and their connections related to transforming inputs into products and services.
Supply networks

Inputs

Activities

Resources

Products & Services

Actors
Supply networks

Figure 6. Logistics chains
Source: Derived from Braithwaite, 1992.
Supply networks in international textile industry

- Fabric producers
- Yarn producers
- Merchandisers
- Designers
- Trims producers
- Garment manufacturers
- Distributors
- Logistics and warehouse companies
- Retail
Supply networks in international textile industry

Brand Managers

- Trims producers
- Garment manufacturers

Fabric producers
- Yarn producers
- Merchandisers

Distributors
- Logistics and warehouse companies
- Retail

Designers
Supply networks in international textile industry

• Now considering this, we can ask if this type organization of a Supply Chain is indeed effective?

• From the literature review is clear that the organization of the textile industry supply chain is *not standard and depends on where it is located in the world and how long the chain is.*
supply networks in international textile industries
Supply networks in international textile industry

• It has been observed that many of the major retailers and brand owners are located in US and EU, which also represent major clothing markets.

• Since the MFA (Multifiber agreement) in 2004, and due to major cost saving policies, apparel manufacturing has been transferred across the newly industrialized countries, developing countries, and under-developed countries.

*MFA: Tried to eliminate the discrimination among countries that limited the import process of some countries through quotas.

*GATT: General agreement on Tariffs and Trades
supply networks in international textile industries
supply networks in international textile industry

• Those developing countries, are nowadays, manufacturers of finished goods or of raw materials.
  – Which are transported to some of the most important markets in the world: US and the EU.
• 10 years ago, it was observed that the region that export more textile supplies to the rest of the world was Asia (4.3%). Followed by countries in eastern europe (2.3%).

Bergvall-Forsberg & Towers, 2007
Supply networks in international textile industry
Supply networks in international textile industry

• However, they recreate the chain as a local version
• Some companies share the installed capacity for local and international brands, but they do not necessarily have the same quality and standards as their international production counterpart.
Supply networks in international textile industry

• This causes disorganization in the production, and some companies have more capacity than they should have.
• Considering this, most of the textile Supply Chain networks have become
  – dispersed,
  – heterogenous,
  – long
  – complex.
supplies networks in international textile industry
Supply networks in international textile industries

• Several studies have shown that raw supplies and manufacturers act in a **global scenario**, while distributions centers and retail networks act in a **local market**.

• The question here is:
  – Does this model apply to every textile supply chain in the world?
  – What is happening in the main producers region?
  – What is happening in countries like Ecuador, are those models still maintained?
What has happened in the Latin American textile industry in the last 40 years

• Most “popular” business model are Small Medium Enterprises (SME) that follow a Traditional Manufacturing System.

• In some countries the SMEs are part of clusters.

• Some governments show preferences to boost national production and consumption.
What has happened in the Latin American textile industry in the last 40 years

• Latin America holds only 1.2% of all the textile exports in the world but the region imports 3.3% of all the textile imports. Followed only by Africa (5.7% importations), Europe (4.3%) and middle east (3.9%).

• Is a labor intensive industry.

• For some countries, clusters are based on collaboration and integration in order to search for effectiveness.

• However in other, clusters only represent the physical space in which a big amount of companies are located were each one competes with the other.
What has happened in the Latin American industry in the last 40 years

• The region does not show an important evolution in the use of **technology**.
• Textile producers face a lot of **problems** most of them regarding:
  • Lack of **specialized skills**
  • Difficult access to technology
  • Raw materials
  • Market
  • Lack of access to **Credit**
  • External services

Guilliani, Pietrobelly & Rabellotti, 2005
What has happened in the Latin American textile industry in the last 40 years

- Were “Clusters” are:

According to the economic literature, industrial clusters are groups of firms on the same location composing a production system with spillovers that can be vertical and/or horizontal.

Madsen et al., 2007
What has happen in the industry in the last 40 years.
What has happen in the industry in the last 40 years.

• Some of the most important clusters in South America are located in Peru, Colombia and Brazil.
• In the picture we can see one of the main clusters located in Peru.
  – This cluster is based on entrepreneurial collaboration.
  – Cotton producers, textile manufacturers and companies that manufacture ready-to-wear clothes collaborate in this industry to be more efficient and more competitive in the international scenario.
What has happen in the industry in the last 40 years.

- Latin America_Employment

Textile industry is one of the main sources of employment. In the world, at least 142 million jobs are created around this industry, having a lot of importance in developing countries.

Mittlehouser, 1997 & Shahin, 2013
The Ecuadorian industry.
The Ecuadorian Industry

- In Ecuador, there are three main industries.
  1. Is the petroleum industry. This is the one that supports the most the country’s GDP.
  2. Is related to agricultural production, above all what concerns to flowers and fruits.
     - The exportation of such goods is very developed and it is the second main source of wealth to the country.
  3. Is one the most important to the country is the manufacturing industry. This one is very heterogeneous. Includes textiles
The Ecuadorian Industry

• The textile industry is part of the manufacturing industry.

• It represented the second most important branch of production in 2010, right after the beverage and food industry.
  – It represents at least 12.29% of this industry.

INEC 2010
The Ecuadorian textile industry.

Activities with more participation in the manufacturing industry

- Food and beverage industry: 56.23%
- Textile industry: 12.29%
- Wood products: 9.48%

INEC 2010
What has happen in the Ecuadorian industry.
Large Ecuadorian companies hold 83.7% of textile production.
What has happen in the Ecuadorian industry.

Location of textile production in Ecuador

<table>
<thead>
<tr>
<th>Province</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pichincha</td>
<td>55.7%</td>
</tr>
<tr>
<td>Guayas</td>
<td>30.9%</td>
</tr>
<tr>
<td>Azuay</td>
<td>6.1%</td>
</tr>
<tr>
<td>Tungurahua</td>
<td>3%</td>
</tr>
<tr>
<td>Imbabura</td>
<td>2.2%</td>
</tr>
<tr>
<td>Cotopaxi</td>
<td>0.9%</td>
</tr>
<tr>
<td>Chimborazo</td>
<td>0.4%</td>
</tr>
<tr>
<td>El Oro</td>
<td>0.4%</td>
</tr>
<tr>
<td>Manabi</td>
<td>0.4%</td>
</tr>
</tbody>
</table>
What has happen in the Ecuadorian industry.
Benefits of the textile industry in Ecuador

- It generates more than 25,000 direct jobs and more than 100,000 indirect jobs.
- It occupies at least 13% of the economically active population.
- It represents approximately 3.1% of total GDP and 19.2% of manufacturing GDP.
Benefits of the textile industry in Ecuador

• Since 2010, new duty measures have been created in order to develop the Ecuadorian textile industry.
  – The aim is to improve the industrialization process and the use of technology in order to reduce prices and increase revenues so as to be more competitive in the regional market.
Benefits of the textile industry in Ecuador

• It exist new measures that are contradictory.
  – The first one considers the introduction of technology in textile industries, because even if the government look for this it also imposes duties that makes this process more difficult.
Benefits of the textile industry in Ecuador

• The second one includes, to move companies to create real clusters,
  – however this is limited since there are more land duties that makes these implementation to expensive for textile industries.

• Nowadays the growth in this industry is estimated to be 1.9% per year. However We face an scenario with very little figures and information.
Ecuadorian Cases

• There are about 3,000 textile industries of different size in the country. (Data hard to find)
• However to understand this it was necessary to analyze some cases of study that would show us how the Textile supply Chain worked in Ecuador.
• For this we analyzed three enterprises of different sizes and each one representing a different actor in the Supply Chain.
* The names of those companies will not presented due to confidentiality agreements
Learning more about Ecuadorian cases
Case No. 1: TCL

- Is considered a medium enterprise.
  - Earnings do not exceed 1 million dollars
- They have been in the market for **33 years**.
- Their main products are fabrics for **sport clothing**.
- They have a national presence.
Case No. 1: TCL

- Recently they are implementing new technology to create more types of fabric.
- They have two distribution channels.
  - TCL retail stores.
  - TCL trucks that deliver for direct clients.
Placing the apparel orders

Quality Control Audit

Fabric and accessories sourcing flow

Semi-finished products flow

Finished products flow

Placing the production orders

Thread suppliers

Chemical suppliers

Other supplies

TCL Purchasing Dpt

TCL Weaving

TCL Dyer

TCL Packing

TCL Head Office

TCL Sales office

TCL Stores

Direct Customers (25%)

General Market (75%)

Quality auditors
Borrowing from Ron Askin presentation. .... The textile industry in Ecuador does these... we have visited quite a few industries and we have observed inventories that are so big that at the end of a period they had to dispose off the material because it was outdated !! And they didn’t know what they had in inventory.

But it’s even worse

Beyond a threshold increasing inventory reduces sales!

- Congestion slows service response
- Inventory is outdated
- Forecast horizons too long for accuracy

Carburetors vs. Fuel Injection
Case No. 2: FCL

- They have been in the market for more than 30 years.
- It is part of one of the most important textile groups of Ecuador.
- Their main products are sports clothing.
- They have a national and international presence.
Case No. 2: FCL

- They have a **horizontal integration** in the Supply Chain that does not include spinning and raw materials.
- They have only one distribution channel.
  - FCL has **one truck** and then send everything to a distribution center.
Case No. 3: BCL

• They have been in the market for more than 30 years.
• It is part of one of the most important textile groups of Ecuador.
• It is in charge of warehousing and distribution of 11 textile manufactures and importers.
Learning more about Ecuadorian cases

BCL

- They take finished goods to the local, regional and international markets.
- Provide services to their suppliers.
- The Distribution Center is 6,500 m².
What about sustainability?

• Sustainability is: The capacity to endure.
  – In ecology the word describes how biological systems remain diverse and productive over time
  – For humans, sustainability is the potential for long-term maintenance of well being, which has:
    • Ecological, economic, political and cultural dimensions.
    • Sustainability requires the reconciliation of
      – environmental,
      – social equity and
      – economic demands - also referred to as the "three pillars" of sustainability
What about sustainability?

• Scope
  – Scope for Supply Chains - SCOR

• Methodologies
  – NTM
  – Others: GHG protocol
  – Similarities
  – Differences
Importance of Sustainability?
NTM

• NTM Methodology (Network Transport Methodology)

Provides:

• **Methods** needed to perform the calculations
• Relevant **default data** to use if no situation-specific data is available.

www.ntmcalc.org
NTM

“*The aim* is to help transport companies and their customers (and others interested) to *evaluate the environmental performance* of their transport activities.”

www.ntmcalc.org
Road transport as covered by NTM

- Includes different types of lorries/trucks designed exclusively for cargo transport on public roads. NTM considers road vehicles:
  - Integrated transport systems (or Transports with re-loadings at integrating terminals)
  - Direct transport – single shipment
  - Direct transport – frequent shipments

www.ntmcalc.org
NTM General Calculation Strategy

• The calculation is of the environmental performance, measured as:
  – energy usage and emissions to air, of a cargo transport with a road vehicle.

• The result of the calculation will be expressed as kilograms emission to air [kg] and use of energy [MJ] per shipment of X tonnes.
General Calculation Process

1. Collect information about the shipment
2. Selection of relevant vehicle type and load capacity utilisation
3. Vehicle operation distance and road types
4. Set fuel type and fuel consumption (FC)
5. Set emission factors and energy content of the fuel
6. Calculate vehicle environmental performance data (energy use and emissions to air) for the operation of the vehicle
7. Compensate for the effect of applicable exhaust gas abatement techniques
8. Allocation to investigated cargo
# Example of Types of Trucks

<table>
<thead>
<tr>
<th>No</th>
<th>Illustration</th>
<th>NTM Nomenclature</th>
<th>ARTEMIS Nomenclature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(no picture)</td>
<td>(LCV) Pick-up</td>
<td>LCV Petrol N1-II / LCV Diesel N1-II</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>(LCV) Van</td>
<td>LCV Petrol N1-III / LCV Diesel N1-III</td>
</tr>
<tr>
<td>3</td>
<td><img src="https://example.com/image1" alt="Image" /></td>
<td>(HGV) Small lorry/truck</td>
<td>RT &lt;=7.5t</td>
</tr>
<tr>
<td>4</td>
<td><img src="https://example.com/image2" alt="Image" /></td>
<td>(HGV) Medium lorry/truck</td>
<td>RT &gt;7.5-12t + &gt;12-14t</td>
</tr>
<tr>
<td>5</td>
<td><img src="https://example.com/image3" alt="Image" /></td>
<td>(HGV) Large lorry/truck</td>
<td>RT &gt;14-20t + &gt;20-26t</td>
</tr>
<tr>
<td>6</td>
<td><img src="https://example.com/image4" alt="Image" /></td>
<td>(HGV) Tractor + 'city-trailer'</td>
<td>TT/AT &gt;14-20 + &gt;20-28</td>
</tr>
</tbody>
</table>
Table 2. Vehicle concepts/types and load capacity.

<table>
<thead>
<tr>
<th>No</th>
<th>Illustration</th>
<th>Max weight¹</th>
<th>Vehicle length (approx.)</th>
<th>Load capacity (typical values, inner dimensions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>[tonne]</td>
<td>[m]</td>
<td>[tonne] pallets [m] [m³] TEU</td>
</tr>
<tr>
<td>1</td>
<td>(no picture)</td>
<td>&lt; 2.5</td>
<td>5</td>
<td>0.6 1 1.8 3-6 0</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>&lt; 3.5</td>
<td>7</td>
<td>1.5 3-5 3-4 10 0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>3.5–7</td>
<td>8</td>
<td>5 14 4-6 35 0</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>7.5–14</td>
<td>12</td>
<td>7 24 7.7 44 0</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>14–26</td>
<td>12</td>
<td>15 24 7.7 44 1</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>14 - 28</td>
<td>12 - 15</td>
<td>15 - 16.5 20-28 8 - 12 50-64 1</td>
</tr>
</tbody>
</table>

¹Given or estimated.
What about sustainability in this supply chain...Case No. 1: FCL

• Description of FCL’s fleet

  Type: 7 HGV small trucks

  Size: 6 tonnes

Motor generation: EURO III
Fuel type: Diesel 2
2. Fuel consumption

- Distance: 80 km
- Road type: 100% urban
- Traffic: stop+go
- Speed limit: 50km/h
- Cargo type: bulks
- LCU: 50%
2. Fuel consumption

**Table 3. Fuel consumption**

<table>
<thead>
<tr>
<th>Road type</th>
<th>FC LCU 0% (l/km)</th>
<th>FC LCU 100% (l/km)</th>
<th>FC LCU 50% (l/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% urban</td>
<td>0.11</td>
<td>0.134</td>
<td>0.122</td>
</tr>
</tbody>
</table>

**Table 4. Energy usage with 50% of load capacity utilization**

<table>
<thead>
<tr>
<th>Road type</th>
<th>FC LCU 50% (l/km)</th>
<th>Distance (km)</th>
<th>FC total (l)</th>
<th>Energy usage (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>0.122</td>
<td>80</td>
<td>80*0.122=9.76</td>
<td>444.47</td>
</tr>
</tbody>
</table>
## Results

*Comparative chart-total emission of substance $i$ for driving 80 km on urban road with a HGV HINO, 6 ton, according to European standard diesel and Diesel 2*

<table>
<thead>
<tr>
<th>Substance</th>
<th>EF (g/l) EU diesel</th>
<th>EF (g/l) Diesel 2</th>
<th>$Em_{vehicle , urban , road}$ (gr o kg) EU diesel - 10ppm S</th>
<th>$Em_{vehicle , urban , road}$ (gr o kg) Diesel 2 - 7000ppm S</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC</td>
<td>1.38</td>
<td>1.38</td>
<td>13.468 gr</td>
<td>0.2158 gr</td>
</tr>
<tr>
<td>CO</td>
<td>5.76</td>
<td>5.76</td>
<td>56.2176 gr</td>
<td>0.8994 gr</td>
</tr>
<tr>
<td>NOX</td>
<td>21.1</td>
<td>21.1</td>
<td>205.936 gr</td>
<td>3.2949 gr</td>
</tr>
<tr>
<td>PM</td>
<td>0.574</td>
<td>0.574</td>
<td>5.60224 gr</td>
<td>0.089 gr</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>0.0083</td>
<td>11.48</td>
<td>0.081 gr</td>
<td>1.8 gr</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>2615</td>
<td>2976.6</td>
<td>25.52 kg</td>
<td>47.6256 kg</td>
</tr>
</tbody>
</table>
$SO_2$ Emissions

DIESEL 2

Estándar EU diesel

0.081 vs. 1.8 gr

Diesel 2 is 95 times more dangerous for the environment
Results - CO₂ Emissions

1 shipment produces 0.007 gr CO₂ per shipment.

360 days

2.59 gr of CO₂ per kwh of energy used/year

Limit permitted in Ecuador – 2.1 gr/kwh per year

*Norma Técnica Ecuatoriana. NTE INEN 2 207:2002
For all the textile companies

• If we assume that each of the 3000 industries use one truck with these characteristics the emissions per year would be:

$$3000 \times 2.59 = 7770 \text{ gr of CO}_2 \text{ per kwh of energy used/year}$$
Conclusions

• The international and Ecuadorian textile industry are very heterogenous and complex to analyze.

• In Ecuador most of the textile industries do not collaborate.
  – Instead they look to create a competition among local supply chains in the local market.
Further Studies

Some of the studies that could be performed in this field are:

• The characterization of supply chain of other textiles industry.

• Analysis of replenishment, operations and distributions of more companies in the textile industry.
Thank you!!