Incorporating Consumer Attitudes To Minimise Waste And Out-of-stock Situations In Food Retail

Emel Aktas
Danqian Wang, Soroosh Saghiri, Zeynep Topaloglu, Tamara van ‘t Wout, Akunna Oledinma, Zahir Irani, Amir Sharif, A. K. Samsul Huda

13 November 2016

www.cranfield.ac.uk/som

This publication was made possible by NPRP grant # [NPRP 7-1103-5-156] from the Qatar National Research Fund (a member of Qatar Foundation). The statements made herein are solely the responsibility of the authors.
Outline

- Background
- Motivation
- Literature
- Methodology
- Results
- Future work

https://blogs.commons.georgetown.edu/safeq/
Background

• **Food Loss**: decrease in quantity or quality of food.

• **Food waste**: removal from the Food Supply Chain of food which is fit for consumption, or which has spoiled or expired, mainly due to
  
  • economic behaviour,
  
  • poor stock management or
  
  • neglect.

Country Info and Food Profile

- **Area**: 4468 sq mi (11,586 km²)
  - Compare: Orlando: 4,012 sq mi (10,390 km²)
- **Climate**: arid with mild, pleasant winters; very hot, humid summers
- **Population (2016 est.)**: 2,545,603
  - Doha (capital): 956,460
- **GDP (2014 est.)**: $298.4 billion (49th)
- **GDP per Capita (2014 est.)**: $145,894 (1st)
- **Human Development Index (2014)**: 0.850 (very high, 32nd)

Source: https://en.wikipedia.org/wiki/Qatar, date retrieved: 10 Apr 16

**Qatar food consumption by product (%)**

- Cereals 35%
- Meat 10%
- Fruits 11%
- Vegetables 20%
- Milk 16%
- Others 12%

**90% imported**

**What Qatar produces for its own needs**

<table>
<thead>
<tr>
<th>Product</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>0.2%</td>
</tr>
<tr>
<td>Meat</td>
<td>10%</td>
</tr>
<tr>
<td>Fruits</td>
<td>11%</td>
</tr>
<tr>
<td>Vegetables</td>
<td>20%</td>
</tr>
<tr>
<td>Cereals</td>
<td>35%</td>
</tr>
</tbody>
</table>

Source: AOAD 2013, Arab Agricultural Statistics Year Book, Alpen Capital, CIRS Georgetown University, Qatar.
WARNING!! Check the expiry date when shopping.

Dear Consumer,

Make sure of expiry date of product when buying and that the product is of good condition. Do not exceed the expiry date under any circumstances.

Source: Baladiya
Motivation

• Perishable products deteriorate and lose value in a short period of time
• Consumers more conscious of the “freshness”
• Retailers face the dilemma: food waste versus out-of-stock
• Perishable inventory management
  ▪ Shelf life
  ▪ Demand uncertainty
  ▪ Order batch size
  ▪ Delivery lead time
  ▪ Customer picking preference
  ▪ Retailer’s actions to change customer picking
• Order-up-to policy
  ▪ Without expiry date
  ▪ With expiry date
<table>
<thead>
<tr>
<th>Literature</th>
<th>Shelf Life</th>
<th>Demand Uncertainty</th>
<th>Order Batch Size</th>
<th>Lead Time</th>
<th>Customer Picking Behavior</th>
<th>Change in Picking Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hu et al. (2016)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haijema, (2014)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Piramuthu and Zhou (2013)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broekmeulen and Donselaar, (2009)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>van Donselaar et al. (2006)</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tekin, Gürler and Berk (2001)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Mena, Adenso-Diaz and Yurt (2011)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Stanger et al., (2012)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Olsson and Tydesjö (2010)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Duan and Liao (2014)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Qin, Wang and Wei (2014)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Chew et al. (2014)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Minner and Transchel (2010)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Zhou, Leung and Pierskalla (2011)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Multiple objectives in perishable inventory management

- Reduce costs of shortages and lost sales
- Reduce costs of inventory
- Reduce wastage
- Improve customer service and loyalty

<table>
<thead>
<tr>
<th>Study</th>
<th>Reduce waste</th>
<th>Decrease shortage/backorder</th>
<th>Reduce average stock costs</th>
<th>Increase profit</th>
<th>Improve service level / others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duan and Liao, (2013)</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharda and Akiya, (2012)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haijema, (2014)</td>
<td>√</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Broekmeulen and Donselaar, 2009</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tekin, Güler and Berk, (2001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gómez et al. (2004)</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Minner and Transchel, (2010)</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

https://blogs.commons.georgetown.edu/safeq/
Methodology

1. A single-product, a single-retailer, replenished by a single supplier.
2. The product is a time dependent perishable product.
3. The order-up-to inventory policy: At the end of each day, an order is placed if the stock position drops below the target order-up-to level. The target level is 1000.
4. Unsatisfied demand is lost.
5. The product is a kind of grocery products with printed expiration date.
6. The units received by the retailer are assumed to be of the same age upon receipt and received products begin to lose their life time once the order is received.
7. The retail staff issue products following FIFO policy.
8. Simulation duration is 365 days.

https://blogs.commons.georgetown.edu/safeq/
### Simulation Inputs and Outputs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Explanation</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>Standard deviation of demand</td>
<td>100</td>
<td>250</td>
</tr>
<tr>
<td>BS (units)</td>
<td><strong>Batch Size</strong>: Ordering quantity is a multiple of the discrete delivery batch size.</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PB (percentage)</td>
<td><strong>Picking Behavior</strong>: Percentage of customers searching for the freshest items.</td>
<td>0.5</td>
<td>0.8</td>
</tr>
</tbody>
</table>

- **DtE (days) = 1**
  - **Days to Expire**: the shelf life of the product, which begin to decline when order is received. For example, DtE being equal to 3 means the perishable goods has 3 days for sale once they are received.

- **LT (days) = 1**
  - **Lead Time**: time elapsed from when an order is until the ordered items are received.

### Outputs

**Out-Of-Stock**: Quantity of stock out per day / Daily demand

**Waste**: Quantity of stock expired per day / Opening Stock

https://blogs.commons.georgetown.edu/safeq/
Preliminary Findings

SD = 100, BS = 50

- PB = .5
- PB = .8

SD = 100, BS = 100

- PB = .5
- PB = .8

SD = 250, BS = 50

- PB = .5
- PB = .8

SD = 250, BS = 100

- PB = .5
- PB = .8
The impact of Days to Expire

Days to Expire

- Average Waste
- Average out-of Stock

https://blogs.commons.georgetown.edu/safeq/
The impact of Lead Time

The graph shows the relationship between lead time and average waste vs. average out of stock. As lead time increases, average waste decreases, while average out of stock remains relatively constant. The data can be found at [https://blogs.commons.georgetown.edu/safeq/](https://blogs.commons.georgetown.edu/safeq/).
Item vs Case Level Waste

**Item Level Waste**

- SD=100
- SD=200
- SD=300

**Case Level Waste**

- SD=100
- SD=200
- SD=300

PB=.3  PB=.5  PB=.7

[Link to website: blogs.commons.georgetown.edu/safeq/]

14
Results

• Out of stock is significantly affected by demand uncertainty
• Shortage is highly sensitive to the lead time for highly perishable products;
• Order batch size has subtle effect on the outcomes
• Unsatisfied demand is more sensitive to customer picking behavior when expiry time and lead time of the product are shorter.
• Tracking expiry date helps reduce food waste and out-of-stock
Conclusions and Future Research

• Studied the impact of
  • Uncertainty
  • Lead time
  • Batch Size
  • Picking behaviour
  • Item level expiry information in ordering decisions

• Limitations
  • Single product
  • No substitution effects
  • Price discounts not included

• Outlook
  • Experiment with longer shelf lives and retailer’s activities to change the picking behaviour incorporating price discounts
Thank you

Questions / Comments?

Emel.Aktas@cranfield.ac.uk

@emelaktas

http://uk.linkedin.com/in/emelaktas/

https://blogs.commons.georgetown.edu/safeq/
References


