THE INTELLIGENT CONTAINER - AN ESTIMATION OF BENEFITS AND COSTS

Marius Veigt, Patrick Dittmer, Rasmus Haass, Franziska Wittig

BIBA - Bremer Institut für Produktion und Logistik GmbH
Hochschulring 20
28359 Bremen
Germany
Phone: +49 421 218 50165
E-Mail: vei@biba.uni-bremen.de

Key words: Intelligent Container, quality driven distribution, cost-benefit-analysis

1 Introduction

During the last decades bananas were mainly imported via reefer vessels. In order to reduce transport costs, importers currently use reefer containers that are shipped by liner cargo services to Europe. While the losses of bananas in the reefer vessels could be kept very low, for reefer containers a trend toward higher spoilage of bananas during transport can be observed. Reasons are very different and range from a false set-point for temperature, to power disturbances, up to spontaneous ripening which may result in a complete loss of all goods within a container.

In order to solve these issues a project consortium has developed the "Intelligent Container" [1]. This container detects autonomously if the set-point of its cooling unit is rightly adjusted as well as if its power supply works properly and alerts the staff to correct errors. Furthermore, the container is enabled to use sensor data and a quality model for bananas to calculate the condition life of its cargo [2].

The project consortium has developed a prototype of the Intelligent Container. In field tests from Central America to Europe, the technical functionality of the container has been demonstrated. A major advantage of the Intelligent Container is the quality driven distribution of goods [3]. This means, the ability of the Intelligent Container to predict the green life can also be used to decide which containers must be handled with priority in the European port, because a spontaneous ripening has started, and which containers can be forwarded, because the loaded bananas still have a long green life. Hence, the losses of bananas during the transport should be decreased.

To explore the level of avoidable food losses by the quality driven distribution more than one Intelligent Container is required. Due to the costs several Intelligent Containers would generate we conducted two simulation studies [3] [4] to find this level. This article describes the results of these simulation studies to estimate a benefit of the Intelligent Container. In addition, we contrast the benefit and the costs of the prototype to estimate the profitability of the Intelligent Container for the considered scenario by using the net present value method.

2 Estimated Benefits

In both simulation studies we used an existing distribution network of bananas, assumed that all shipped containers are “intelligent” and their data would be used to distribute the goods. The considered logistics network for banana distribution is characterized by one origin in Central America and numerous possible destinations in Europe. In this network European ports in Belgium and in

Germany are used. Once a container is unloaded at one of these ports, it may be transferred to Scandinavia by vessel or to a ripening facility by truck.

During the transport the containers are cooled to approximately 14°C. During this time, the ripening process of the bananas is slowed down and in most cases the bananas arrive at their destination in the demanded condition. However, there are various reasons effecting a spontaneous ripening inside the container. Until today the banana ripening process is not understood in every detail. Therefore, we use a simplified ripening function as well as various probabilities to start a spontaneous ripening in the simulation [3] [4].

Due to the spontaneous ripening the condition of the bananas change and the Intelligent Container provides the information about these changings. This information is used to decide which container can be forwarded to Scandinavia and which container has to be handled with priority. Thus, the Intelligent Container can fulfill more orders than a conventional reefer container and food losses can be reduced.

As a result of the simulation we state that Intelligent Containers can reduce the food losses between 20% and 50% within the considered scenario [3] [4]. The amount of the reduction depends on several factors such as the network size, the amount of orders, the amount of losses, the probability of a spontaneous ripening as well as the ripening progress (ripening function).

Besides reducing food losses the Intelligent Container has further benefits. For instance, the precise temperature monitoring can be used for a more efficient cooling [5]. Due to the online condition monitoring of the goods the amount of manually performed quality checks can be reduced. This leads to faster handling times e.g. within the ports.

3 Estimated Costs

For analyzing the cost structure we use the method of the total cost of ownership (TCO), which considers the cost of a product or an investment over its entire life cycle [6]. However, we only consider costs which are additional to a conventional reefer container.

The TCO for the implementation of the Intelligent Container is divided into the non-recurring costs and recurring costs. The non-recurring costs are ordered into costs for the Freight Supervision Unit (FSU) including the telematics and the ethylene sensor, sensor nodes (with temperature and humidity sensors), further equipment (charging stations and hand-helds) and other costs (employee training and development of a quality model).

Furthermore, there are annual recurring costs which consist of process costs (handling of the sensor nodes), maintenance and repair, communications, energy and disposal costs. The total cost is highly dependent on the application areas. They depend on the number and type of the mode of transport (truck or vessel), the amount of tagged pallets per container, and the amount and duration of the transport.

In our scenario there are 20 pallets in each container, every other pallet is equipped with a sensor node. The transport from the origin to the destination takes around 26 days. Hence, we assume that a container is available every 52 days at the origin (a buffer time is included, e.g. for maintenance) and it can perform 7 transports per year. In our scenario we need 780 containers to perform effectively. We calculate 10 years as the life time of a container, except for the sensor nodes, these have to be replaced approximately every 3 years.

Table : Cost overview

Non-recurring cost	**€**
FSU + Telematics + Ethylene Sensor (1,900 € per Container)	1,482,000
Sensor Nodes (500 € per Container)	390,000
Equipment & Supplies	405,800
total	**2,277,800**
Recurring costs per year	**€**
Process Costs (Integration + Separation of Sensor Nodes in Boxes)	169,000
Maintenance + Repair + Replacement of Sensor Nodes	220,002
Communication Costs (via Satellite)	265,953
total	**654,955**

Additionally to the recurring costs there are energy and disposal costs. The technical devices such as the FSU consume energy; however, there is also the possibility to save energy due to a more efficient cooling. Probably, energy costs and savings will balance each other. The disposal costs will be equal to a state of the art reefer container. Consequently, we do not consider these costs.

Due to economies of scales there are less recurring costs per container the more containers are purchased. Numerous containers allow an aggregation of packets with the sensors back to the origin, less charging stations per Container would be required and the costs of developing a quality model are shared.

4 Cost-benefit-analysis

The NPV is the sum of all deposits and withdrawals discounted on one date caused by an investment object. For the cost-benefit-analysis we use the net present value method with the following formula [6]:

$$NPV^{IC} = -C_0^{IC} + \sum (B_t^{red} - C_t)/ (1+i)^t$$

NPV^{IC}	net present value Intelligent Container
C_0^{IC}	non-recurring costs Intelligent Container
B_t^{red}	savings through the reduction of loss (benefit)
C_t	recurring costs
i	Interest rate (8%)
t	period
T	life cycle of the Intelligent Containers (=10 years)

In our simulation we expected that nowadays the food losses of perishables during the transport are around 5% [7]. As in section Estimated Benefits described 20% up to 50% of these food losses can be avoided. The goods value per box with bananas was in 2012 around 14 € [8]. In our scenarios 48 boxes are stacked at each pallet and 20 pallets are loaded in a container. Thus, the value of each container is 13,440 €. In the considered scenario there are 780 containers which are used 7 times per year and 5% of the bananas spoil. Consequently, the value of the spoiled fruits is almost 4 Mio. €. As the simulation results have shown, up to 2 Mio. € per year can be saved.

We calculated the NPV over 10 year for the different possibilities of savings. The following figure illustrates the results.

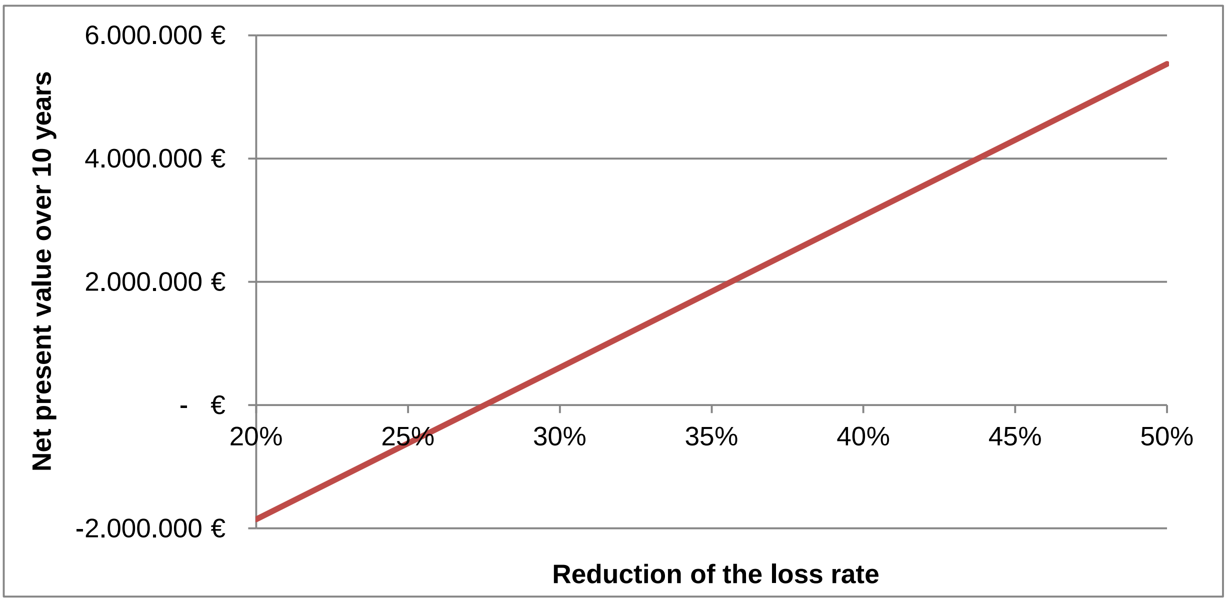

Figure : Devolution of the net present value depending on the loss rate reduction

In this paper, the reduction of food losses is explained particularly as a benefit of the Intelligent Container. However, with the implementation other benefits can be generated as well. Through optimized processes and processing time labor costs can be reduced and storage and transport costs can be saved. Finally, the Intelligent Container can be seen as a competitive advantage, which makes it possible for a company to gain new customers.

5 Conclusion

In this contribution we presented results of two simulation studies which show a potential of the quality driven distribution of perishable foods by Intelligent Containers. We state that 20% to 50% food losses can be reduced by a quality driven distribution in the considered network. However, there are uncertainties in the simulation; for instance the ripening function as well as the probability of spontaneous ripening during the transport. At this point further research is required to understand precisely the process of spontaneous ripening during the transport.

Furthermore, we calculated the profitability of Intelligent Containers in a scenario. Therefore, we contrasted the total cost of ownership (additional costs in relation to a state of the art reefer container) with the simulated benefit by using the net present value method. As a result the importance of the loss rate for the profitability is demonstrated. Nevertheless, there are also other factors which are influencing the profitability. For example the benefits can be increased by a higher goods value. On the other side we recognize falling prices of sensor nodes and we guess that costs can be decreased by economies of scale resulting through the purchase of several Intelligent Containers. Additionally, further monetary savings through the reduction of personnel, storage, and transport costs are possible. Hence, we state that Intelligent Containers can generate a valuable contribution to the subject of food waste nowadays and it will be profitable in the future.

6 Acknowledgment

This research was supported by the German Federal Ministry of Research and Technology within the joint research project “The Intelligent Container”. For further information please visit www.intelligentcontainer.com.

7 References

[□] http://www.intelligentcontainer.com/konsortium.html
[2] Jedermann, R., et al. Sea transport of bananas in containers – Parameter identification for a temperature model. Journal of Food Engineering, Volume 115, Issue 3, April 2013, Pages 330–338, http://dx.doi.org/10.1016/j.jfoodeng.2012.10.039
[3] Lütjen, M.; Dittmer, P.; Veigt, M.: Quality driven distribution of intelligent containers in cold chain logistics networks. In: Production Engineering Research and Development, 7(2013)2, 291–297 pages
[4] will be published soon
[5] Jedermann, R.; Moehrke, A.; Lang, W.: Supervision of banana transport by the intelligent container. In: Kreyenschmidt, J. (ed.): Coolchain-Management, 4th International Workshop. University Bonn, Bonn, 2010, pp. 75-84
[6] Daniel Gille, Wirtschaftlichkeit von RFID-Systemen in der Logistik, Wiesbaden 2010
[7] J. Gustavsson and C. Cederberg et al, Global Food Losses and Food Waste. Available: http://www.fao.org/fileadmin/user_upload /ags/publications/GFL_web.pdf (2012, Jan. 03).
[8] CIRAD-FruitTrop; The European banana market in 2012. In: FRuiTROP, No. 207, January 2013, pages 27-28