POLITECNICO DI MILANO

School of Industrial and Information Engineering

Master of Science in Management Engineering

Intelligent Modular Unit (IMU) Project: Cost and Benefits Analysis on Implementation of Shelf-ready Packaging - An Empirical Study

Supervisor: PERO Margherita Emma Paola

Author:

PINNATA Ruben Indurain

Academic Year: 2018/2019

ACKNOWLEDGEMENT

TABLE OF CONTENTS

Table of Figures, Equations and Tables

ABSTRACT

According to surveys performed by Efficient Customer Response (ECR) in 2016, a significant number of out of stocks occur in the last 50 meters [1]. It is not easy for the shop managers and personnel to identify the back-house availability of items and replenish on time without damaging the goods or replenish efficiently the shelves without discouraging customer who are going to buy the goods. Another study which complements this finding was done in 11 countries, 115 categories and responses from more than 20,000 shoppers shows that 30% [2] of these shoppers responded that out-of-stock is in their concern, falling to third position only to requiring shorter queues and asking for more promotions. This 30% surely an indicator that increasing on-shelf availability is an important issue also in Fast-Moving-Consumer Goods industry.

The problem of reducing out-of-stock or, can be taken also as improving on-shelf availability could not be solved by implementing one solution. However, one of them is the implementation of Shelf-Ready Packaging (SRP). In this study, the SRP would be named Intelligent Modular Unit or IMU which is how Barilla make their version of SRP. These IMU versions would be launched in 2019 in 3 different waves. The IMU versions would be designed according to the 5 functional requirements according to ECR Europe: Easy Identification, Easy Open, Easy Dispose, Easy Shelf and Easy Shop.

This study would focus on the Easy shelf and Easy Shop requirements and to be presented in a quantitative analysis. The study does not cover the whole change and would only use the data of the IMU switching plan from week 1 of 2019 to week 31 of 2019 due to time constraint of the analysis. The Easy Shelf analysis revolves around the space optimization which is measured by calculating the consumer unit change analysis, dimension saturation change analysis, pallet change analysis and finally the impact of pallet change, if any, to transportation cost and storage cost. Meanwhile, the Easy Shop requirements revolves around the possibility to use IMU versions to either replace the existing repacked old versions or replace the complexity in building display units by being stackable. These repacked items used to serve the same functions as SRP and now since they would no longer be repacked locally but to be produced centrally, this stop of repacking activities may result in cost change for Barilla. The study relies on data from Barilla and would be presented in percentage to protect data confidentiality. The result shows that in terms of quantitative analysis, the implementation Easy Shop and Easy Shop do not contribute to a high cost change.

SINTESA DEL LAVORO

Secondo le indagini condotte da *Efficient Customer Response* (ECR) nel 2016, negli ultimi 50 metri si verifica un numero significativo di scorte esaurite [1]. Non è facile per i responsabili e il personale del negozio identificare la disponibilità degli articoli nel back-house e rifornirli in tempo senza danneggiare la merce o rifornire in modo efficiente gli scaffali senza scoraggiare il cliente che intende acquistare la merce. Un altro studio che integra questo risultato è stato condotto in 11 paesi, 115 categorie e risposte di oltre 20.000 acquirenti, dimostrando che il 30% [2] di questi acquirenti ha risposto che l'esaurimento è nelle loro preoccupazioni, cadendo in terza posizione solo per code più brevi e chiedendo più promozioni. Questo 30% indica sicuramente che l'aumento della disponibilità a magazzino è un problema importante anche nel settore dei beni di largo consumo.

Il problema di ridurre le scorte esaurite o, può anche essere preso in quanto il miglioramento della disponibilità a magazzino non potrebbe essere risolto implementando una soluzione. Tuttavia, uno di questi è l'implementazione di Shelf-Ready Packaging (SRP). In questo studio, l'SRP verrebbe chiamato *Intelligent Modular Unit* o IMU, che è il modo in cui Barilla realizza la sua versione di SRP. Queste versioni di IMU sarebbero state lanciate nel 2019 in 3 diverse ondate. Le versioni IMU sarebbero state progettate secondo i 5 requisiti funzionali secondo ECR Europe: Easy Identification, Easy Open, Easy Dispose, Easy Shelf e Easy Shop.

Questo studio si focalizzerà sui requisiti Easy Shelf e Easy Shop e verrà presentato in un'analisi quantitativa. Lo studio non copre l'intero cambiamento e utilizzerà solo i dati del piano di commutazione IMU dalla settimana 1 del 2019 alla settimana 31 del 2019 a causa di vincoli temporali dell'analisi. L'analisi Easy Shelf ruota attorno all'ottimizzazione dello spazio che viene misurata calcolando l'analisi del cambiamento delle unità di consumo, l'analisi del cambiamento di saturazione dimensionale, l'analisi del cambio pallet e, infine, l'impatto del cambio pallet, se presente, sui costi di trasporto e sui costi di stoccaggio. Nel frattempo, i requisiti di Easy Shop ruotano attorno alla possibilità di utilizzare le versioni IMU per sostituire le vecchie versioni riconfezionate esistenti o sostituire la complessità nella costruzione di unità di visualizzazione essendo impilabili. Questi articoli *repacked* erano utilizzati per le stesse funzioni di SRP e ora poiché non sarebbero più stati *repacked* localmente ma per essere prodotti centralmente, questa interruzione delle attività di *repacking* potrebbe comportare una modifica dei costi per Barilla. Lo studio si basa sui dati di Barilla e verrebbe presentato in percentuale per proteggere la riservatezza dei dati. Il risultato mostra che in termini di analisi quantitativa, l'implementazione di Easy Shop e Easy Shop non contribuisce a un cambiamento dei costi elevato

I. Company Profile

A. Company Background

Figure 1. Barilla logo in 2019

Barilla was founded in 1877 at Parma by Pietro Barilla in a form of a little shop selling egg pasta and bread. Its first factory opened and remained a family company, then passed down from generations to generations, until it gained a leadership in pasta-making industry in 1958. It was sold once to investors from United States of America, but then rebought and rebuilt until it becomes what they are today. Today, 142 years later, Barilla has established itself as a leader not only in Italy, but also in the world as a pasta-making company. It also diversifies itself into other segments such as biscuits, breads and even cross-segments such as restaurant industry and kitchen consultation. Barilla now has 14 brands under its management which are manufactured in 28 production plants and mills which serves over 100 countries around the world.

To measure its performance, Barilla has created a complicated product hierarchy to list and control the performances of its products. Until today, Barilla has 1545 product names registered under its name which extends to over 7000 of item codes. The number of item codes explodes due to different codes may be given to the same product in different region. Different regions would have different codes since those items require different packaging with different languages printed as a part of the law to sell them.

Barilla acquired other pasta brands such as Voiello from Naples, Misko from Greece and Filiz from Turkey to gain more market share and to gain access to new distribution channels while Wasa, a Swedish crispbread company from Sweden and Harry's, a soft bread company in France as a part of its product diversification. Mulino Bianco itself has produced other brands such as Gran Cereale which is labelled as a healthier option of cookies by using whole grain and Pan di Stelle (which, for example, recently produces a spreadable to compete in hazelnut spreadable industry). Barilla is also trying to diversify its market by using its knowledge on the food industry and developed Casa Barilla Restaurants and Cucina Barilla. Casa Barilla opens two restaurants in the United States of America, trying to introduce the products to its final customers while Cucina Barilla is a consultation company, providing consultations on kitchen design.

Despite being a privately-owned company, Barilla published its financial statements annually and describe the condition of the market and the company. These statements allow Barilla to communicate its values and its vision to its customers and society which affects Barilla's long-term strategic plan. Such summary would be presented in the next chapter, chapter B.

B. Business review 2017

Figure 2. Barilla Mission Logo

Barilla's mission is **Good for you, Good for the planet.** Through this mission, Barilla is trying to promote the Mediterranean diet which customers can follow by using Barilla's products. To implement this mission in its products, Barilla focuses on all stages of its supply chain, from raw materials to consumption. In its sourcing decisions, Barilla has contracted farmers and measured their consumption of water, trying and innovating to produce highest quality of wheat, tomatoes and other produce and eliminating palm oil from all its products. Barilla also develops pasta using whole grain wheat or *pasta integrale* and *cinque cereali* to offer healthier options, vegetarian sauces, gluten-free pasta to satisfy its customers, and pasta with colors from different types of vegetables to promote its intention in feeding the planet with healthier food.

In terms of its market competitiveness, Barilla gained 3% [1] increase from last year and enjoy a growth of market value in United States of America, Brazil, Mexico and Canada. Russia also shows a significant increase in volume, which results in them being an important emerging market for Barilla. Despite the growth, Barilla, along with all companies in Fast-Moving Consumer Goods market (FMCG) face the same problem of revenue growth. Most of the revenues growth of multinational companies are slowed down due to competition from smaller but much more agile companies. According to these insights, Barilla understands that keeping customers loyalty is important and tries to listen to the customers' needs, with one of them being to develop products with Shelf-Ready Packaging. The development of Shelf-Ready Packaging in Barilla is named **Intelligent Modular Unit, or IMU** which would be developed for semolina Pasta products. From the development of IMU projects, Barilla is expected to provide benefits for its customers in the form of

increasing shelf availability, increase shelf-replenishment effectiveness and increase the product variety to be put on shelves [2]. For Barilla itself, the latter also provides a benefit, mainly where the on-shelf space for Barilla is low, which justifies the investment invested in the project.

II.   Barilla Supply Chain

Before going on with the IMU analysis, a summary of Barilla's Supply Chain is presented in this chapter. This chapter is segmented into five segments: Organizational structure of supply chain, Barilla's network, the Sales Area Structure, the Transportation and finally, Order Booking & Material Handling. The first segment, the organizational structure would explain a complete picture of the whole players in Barilla supply chain department and their roles, specifically the department where the author was during this project. The second segment, Barilla's network explains how Barilla's network is designed and Barilla's integration with 3PL. Finally, the third segment, fourth and fifth segments explain how orders are processed in SAP in Barilla.

A. Organizational Structure of Supply Chain Department

I.   Overview

Barilla's supply chain department is led by a Chief Supply Chain Officer (CSCO) which directly reports to the CEO. The structure is presented in Figure 3 as follows:
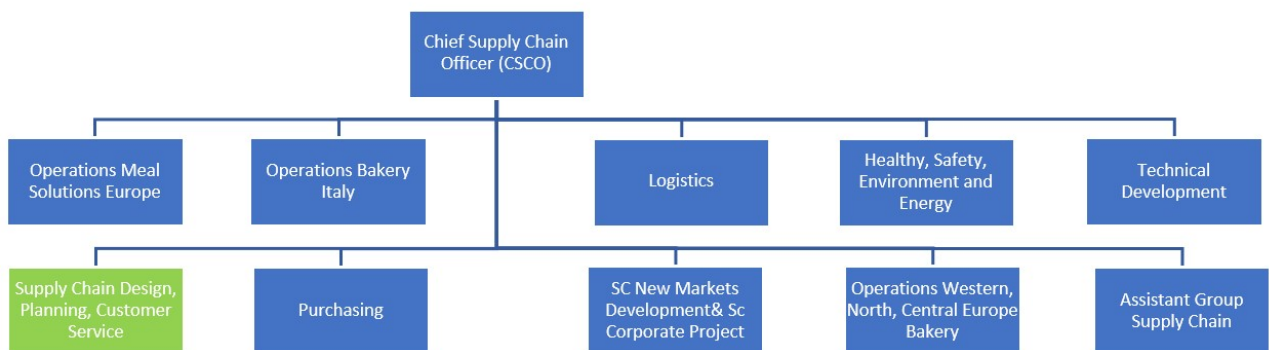
Figure 3. Organizational Chart of Supply Chain Department Barilla

As shown above, there are 10 sub-department which report directly to CSCO: Operations department, segmented into three: Meal Solutions Europe, Bakery Italy and Bakery for Western, North, Central Europe, Logistics department, Technical Development department, Health, Safety, Environment and Energy department (HSEE), Assistant Group Supply Chain and Finally Supply Chain Design, Planning, and Customer Service department. Within this study, the focus would be on the department in green: Supply Chain design, Planning and Customer Service as the author is

placed under this department. Within this department, there are divisions which are shown on Figure 4.
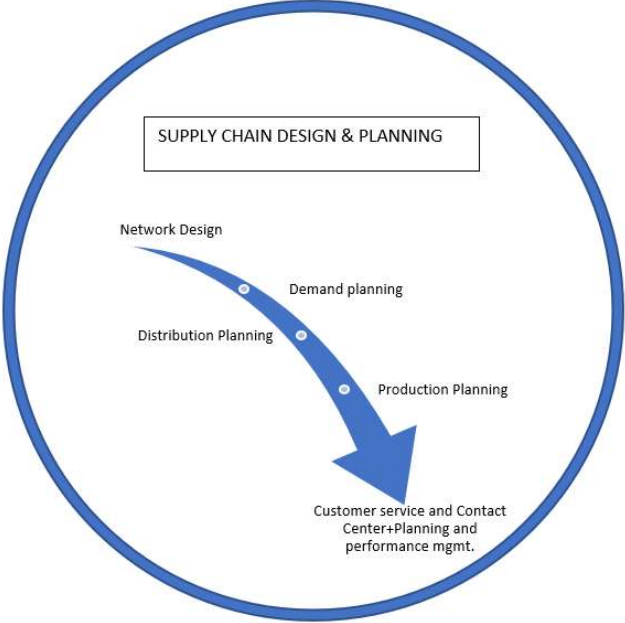
Figure 4. Organizational Chart from Upstream to Downstream

The Roles and responsibilities of each division are presented in the tables below:

Department	Responsibility
Network design and KPIs monitoring	In charge of industrial competition analysis, Industrial asset networks sizing and source allocation and creating standard definition of KPIs, planning processes and systems.
Supply Chain Customer Service	As a competence center for market unit local customer service in execution of the logistics deliveries by clients' orders, support market unit in definition and activation of Road to Market (RTM), and support market units in the improvement of service to customers at best total delivered cost
Integrated Planning (demand planning, production planning and distribution planning)	In charge of demand planning of sales forecast with local market units' area demand managers, production capacity planning and total stock levels accountability,

	replenishment to Barilla network and to customer (including VMI distribution) according to service level requirements and delivery cost.

Table 1. Responsibility of each Department

II.   Customer Service and Contact Center

Since the author performed the analysis whilst being in the Customer Service and Contact Center department, this department is explained further. The goal of the customer service and contact center is to guarantee a good and improving service to customer at sustainable costs, trying to give the utmost efficiency being the global integrated unit for process control and harmonization, supporting local teams in the order to delivery processes.

In order to achieve this goal, there are 4 major activities which are performed:

- Support of Non-integrated countries

  For the countries under this category, central Customer Service and Contact Center perform order management, replenishment support, out of stock management and priority management. It also helps during new product launches within these markets

- Support of Integrated Country

  Helps to process the know-how and established a first point of contact for competence center organizations and finally maintain KPI and manage projects and their implementations

- Competence center

  The department processes the custom document T2L order to deliver process know-how, develop specific order to delivery sub process know-how, documentation and knowledge management, develop 2nd level of contact for competence center organizations, and finally to report and define KPI on action plans.

- Projects

  New sales channels exploration, 3PL integration, logistics network changes, product launches and switches, finally to manage fiscal and administrative implications on Order-To-Delivery process.

B. Barilla's Network

I. Italy
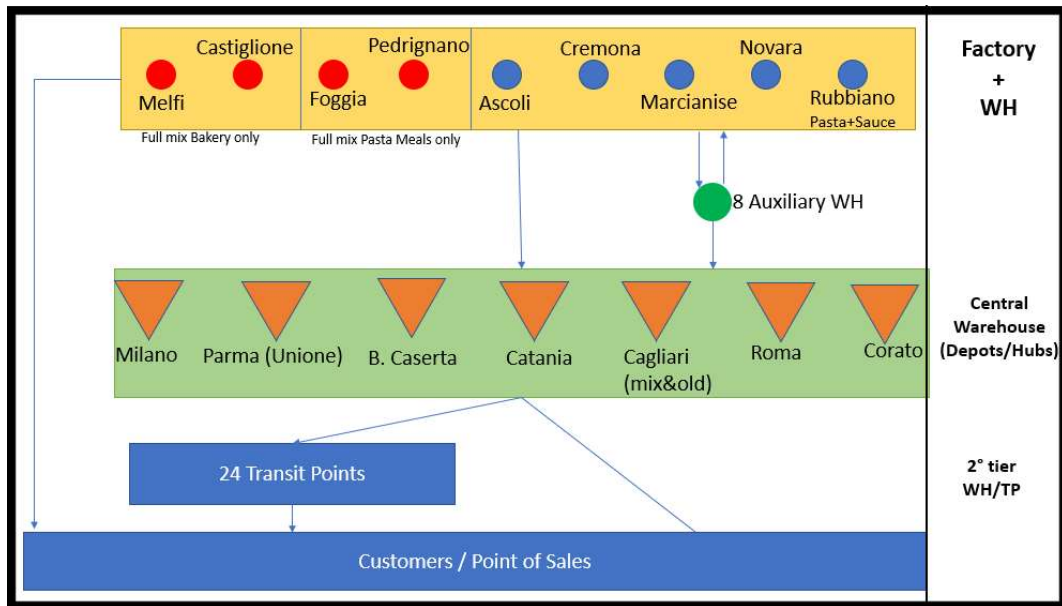
Figure 5. Network Design Italy

In Italy, the arrangements of networks are more complicated compared with other countries due to a larger complexity of orders. In Italy, out of 10 production plants only 4 which produce the whole production mix: Melfi, Castiglione, Foggia and Pedrignano. Pedrignano produces whole mix of pasta meals and Castiglione produces whole bakery mix in the north of Italy while in the south, there are Foggia and Melfi which produce whole pasta mix and whole bakery mix; respectively. The other 5 plants do not produce the whole mix but are used to produce specific items based on seasonality and 1 plant in Rubbiano is specialized for sauces.

The first tier of the network consists of 8 central warehouses which are called as ''Hubs''. These hubs are in strategic positions which can cover their surroundings within hours. These central warehouses are connected to several transit points and auxiliary warehouses to help optimizing the flow and deliver the goods. The hub in Milan covers Lombardia, Piemonte, Trentino, Friuli-Venezia Giulia, a part of upper Liguria and Veneto while the hub in Parma covers southern part of Liguria, Emilia-Romagna, Tuscany, Marche, and Umbria. The hub in Rome covers region of Lazio and Abruzzo while the hub in Caserta and Corato covers Molise, Napoli, Basilicata and Puglia while Catania covers Sicily and Calabria. Finally, Barilla has a hub in Cagliari to cover the island of Sardinia. All these hubs are supplied directly and exchanged items from the plants even from those which are far from each other. This capability allows Barilla to ensure the fulfillment of its customers' orders. Being mainly used to quicken the delivery time only, the flow passing from hubs to final clients only made up to 18% of the flow from production

8

plants. The second tier consists of either a transit point or an auxiliary warehouse. The flows passing from these second tier reached almost 50% of the direct delivery. The flow passing to tier 2 mainly consists of small orders in which are aggregated to optimize transportation.

The logic behind the network design is as follows, For the first tier:

Product Range Consolidation	Order Cycle Time Reduction	Transportation Costs Reduction
MEDIUM	**YES**	**YES**
Barilla has only 4 total-mix production plants in Italy and the specialization of other 5 plants are quite low. Beneficial, but not so much.	Barilla benefits from Order Cycle Time reduction in areas that are far from production plants, especially in southern Italy.	Barilla's products are considered to have low volume density. Having a warehouse increase the saturation of transportation

Table 2. Network Design Considerations

For the 2nd tier, Barilla generally do not benefit in order cycle reduction due to the coverage and the positioning of central warehouses/ hubs are already very strategic. However, Barilla can benefit on the further reduction of transportation cost. Having 2nd tier warehouses or transit points helps Barilla to have more connections to more places and able to assemble the orders much closer to the final destination, therefore having higher flexibility and shorter last-mile delivery which is beneficial for products with low-value density.

II.   Warehouse Integration Model

To perform some of its logistics function in Italy on outside Italy, Barilla contracts Third-party logistics (3PL). 3PL is the owner of the Transportation Planning activities and the carriers booking. 3PL performs the goods booking, pick, pack and goods issue. Barilla communicates to 3PL by a (.TXT) file the sales documents in order to allow the transportation activities and deliver the products to Customer.   3PL sends to Barilla a file containing all information related to the good movements performed. The goods movements that Barilla receives allow the delivery creation and the goods issue/goods entry posting on SAP System.

Besides these basic tasks, recently 3PLs are also required to inform the Dispatching Advise (DESADV) to inform customers so that they can prepare themselves in receiving goods and finally to deal with discrepancy of goods from customers.

The flow of information and goods are presented below:
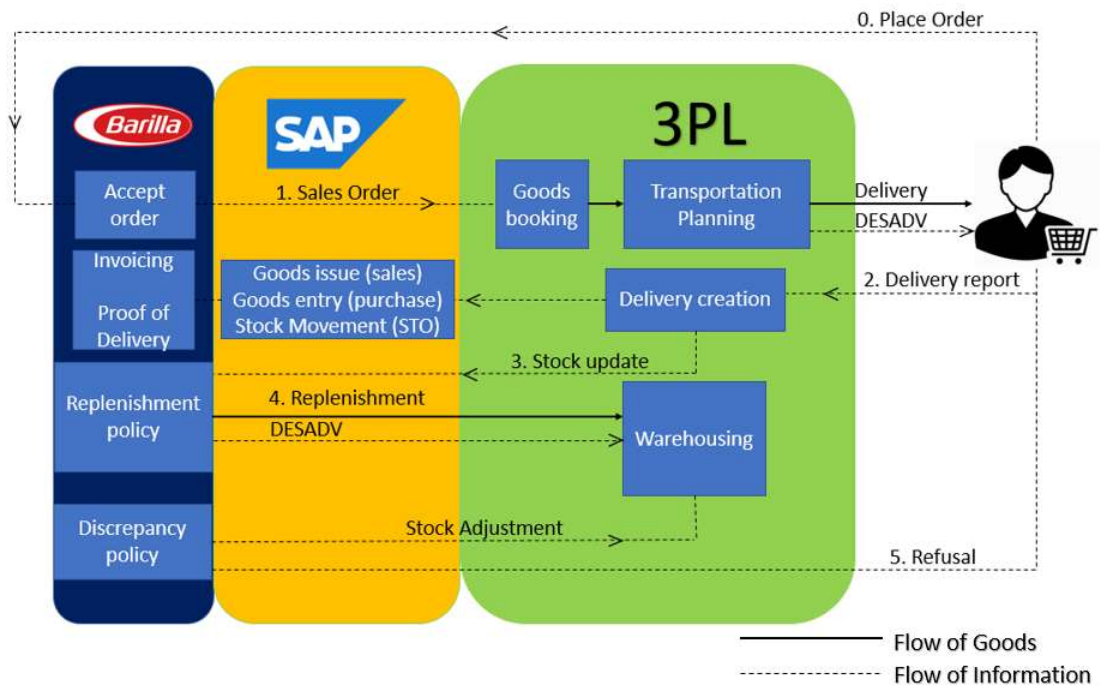
Figure 6. Information flow between Barilla and 3PL

Some examples of 3PLs contracted by Barilla in each country:

Figure 7. Example of 3PLs on Different Countries

C. Sales Area Structure
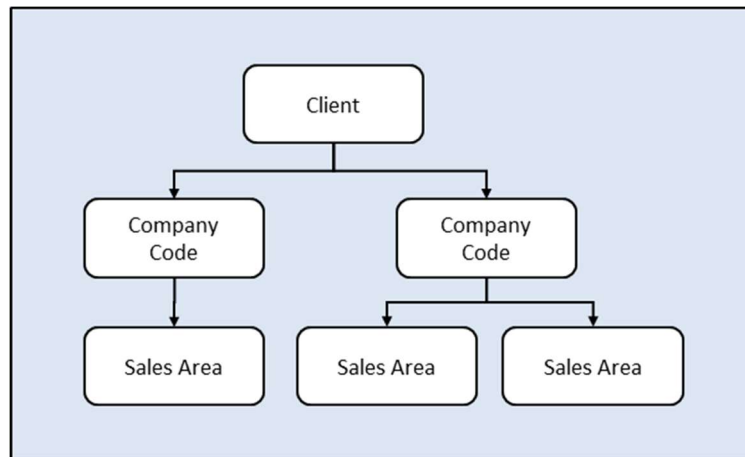
Figure 8. Sales Structure

Barilla, here represented as a client, may have more than one company codes. These company codes are called legal entities, which are independent accounting units within Barilla with their own income statement and balance sheets. For each company codes, there are sales area covered and this can be more than one. Sales area represent the way a company code is organized to serve its customers and is considered an important element for the sales and distribution.
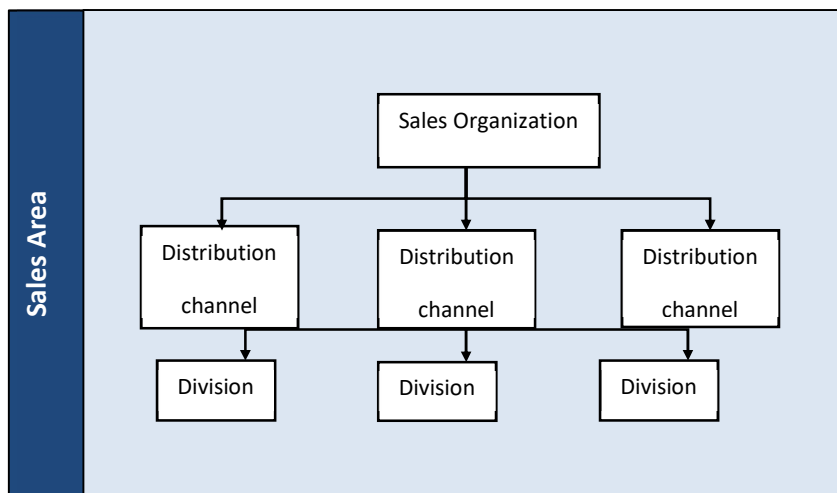
Figure 9. Sales Area

Sales area can be further segmented into three elements: Sales Organization, Distribution channel and Division. Firstly, sales organization represents a single unit that is sold by Barilla to its customers. This unit can be domestic finished goods, export finished goods, intercompany flows, not finished goods, or service sales. Secondly, distribution channel represents a classification of customers within the same sales organization. A customer who belongs to a specific distribution channel is usually served by a dedicated sales force, for example: modern trade for common business customers that buy finished products, food service customers, distributors, not-finished-goods customers, export, intercompany, or copacker (subcontractor who perform repacking activities for Barilla's products).

11

Thirdly, division represent groupings of materials which have the same characteristics in sales and distribution point of view.

This structure of Sales Area is important since this is the way an order is differentiated in Barilla. After the orders are registered under a Sales organization, a distribution channel and a division, an order can be processed which follows a process called order to delivery (OTD).

i.   *Order-to-Delivery*

The order to delivery means the process or steps it is required from the placement of the order until the orders are delivered, and the materials are handled.

The steps of Order-to-delivery (OTD) can be presented in Figure 10:
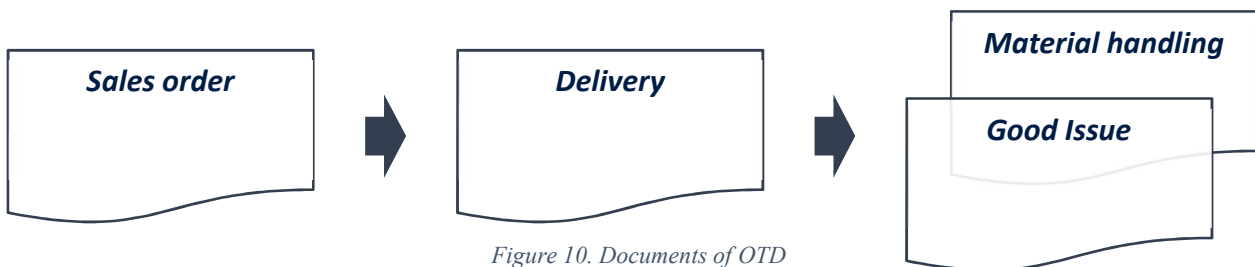
Figure 10. Documents of OTD

The sales order consists of all the process in inserting an order by defining the order type, the customer which purchased the goods, the sales area, the acquisition channel and the ordered items with quantity. The orders would also need to have labelled with logistics information such as a loading date, loading modules, loading type and pallet type. After the order is placed, a business saturation is placed for all the controls as mentioned on figure 11. However, the validation would only be applied when the following business requirements are satisfied:

- ✓ **Feasibility of the delivery date**: a certain period is needed between the acquisition date and the delivery date.
- ✓ **Order Saturation:** the ordered quantity must be inferior to the maximum capacity of the mean of transport.
- ✓ **Credit check:** the value of the order needs to be inferior to the credit limit of the customer and there must not be other orders in credit block.
- ✓ **Handling unit and quantity check:** coherence between the handling unit used and the ordered item quantity in cases.
- ✓ **Double order / item**: the order cannot contain any item which is repeated twice in the same order.
- ✓ **Item opened for the sales organization:** the item must be opened in the system for the sales organization of the order.

Figure 11. Different Checks during Order Placement

a. *Saturation Check*

Barilla receives orders only in trade units (TU) which consist of multiple consumer units that are found in retailers. Barilla does not process orders that are less than a pallet. Therefore, SAP automatically calculates the quantity inserted and determine whether such order can be processed or not.

b. *Payment condition*

During registration of customers into customer master data, customers need to specify their preferred method of transaction and their account number. When this account number has been altered for any reason, such as during a change of purchase channel, the order will be blocked.

c. *Delivery date check*

To ensure the customer service, Barilla would avoid giving promises that would never be satisfied. Thus, the users would be warned if a requested date of delivery does not respect the

minimum estimated time based on the order processing days (4 days) and lead time depending on the location of the country.

d.   Double item/order check

SAP would automatically warn the users when an item is mentioned more than once with the same quantity

e.   Item Sales permission

Barilla gives different codes for the same product with different language printed on the labels. To avoid confusion or to avoid a contamination of items that are not shouldn't be sold in certain areas, the items inserted would be automatically checked whether it is excluded or not for sale in the ship to region.

f.   Pallet management

Pallet is an asset that needs to be managed by Barilla. Pallets preference must be specified in the customer master data whether they would use no pallet, rented pallet, interchange pallet or finally if the pallet is invoiced with the items. When a different selection is selected, the order will be blocked

g.   Credit Check

Financial department oversees collecting information regarding the potential customers' financial health. Information such as credit ratings and the amount of debt are requested in order to set the credit lines given to the customers. During purchasing, a customer might have at least one or these three credits: **Receivables from ordered goods, Receivables from foods in delivery** and **Receivables from delivered goods.** The first receivable is for the orders that have been submitted yet to be processed, the second is from the goods that are on their way and finally from the goods that have been delivered and accepted but awaiting payment based on the Days of Payables Outstanding of the customers. The combination of these three receivables should not surpass the credit line set during the registration of customer master data. When the line is violated, the customer should not be able to have his next orders registered.

h.   Handling unit check

SAP checks the compatibility between the loading type and the loading module. One loading module is associated with one mean of transportation which have certain limits such as weight,

volume and pallet places based on national requirements and the loading type is how an item is loaded on the truck whether with pallet, non-pallet, or with special configuration. When a loading type inserted does not match with the loading module inserted, for example, if there are 66 pallets with loading type one pallet+layer with normal truck as a loading module, the order would not pass handling unit check as the resulting height would be too high and does not pass handling unit check in terms of volume. The same procedure follows for weight and number of pallet places.

After the sales order, the delivery is performed which is by order grouping in a shipment (for the non-saturated orders), carrier hiring and slot booking. After these steps, material handling and goods issue are performed. The final step would be, during the shipment day, a report is performed on the difference between ordered and sent. Only the actual shipped items would be invoice and needed to be paid.

ii.   *Acquisition Channel*

There are multiple channels in which an order can be placed from. This order can be created automatically or manually via the headquarter with three different channels: through Sales Force Automation or SFA, Electronic data interchange (EDI) or through Just-In-time management which are for VMI customers. The SFA are channels used by sales force in which the platform is more user-friendly and can be easily used and learnt, while the EDI is where a customer places their own orders and have them sent to Barilla with a standardized format to be recognized by Barilla's system. Finally, the VMI customers would be explained at the last chapter of the study.

The difference between these methods are the complexity in placing an order. The difference between complexity is shown on figure 14 below
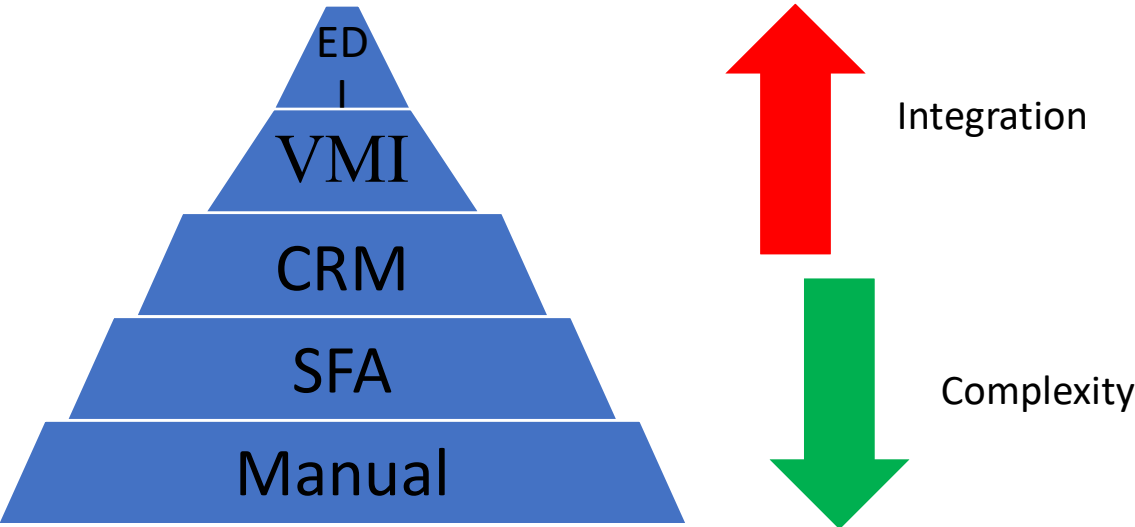
Figure 12. Level of Integration of Acquisition Channel

During this phase, the following details are defined:

Identity	Sold-to Party	the organization that purchased the goods
	Ship-to Party	the address of the organization that will receive the goods
	PO number	how the customers recognized the order in their database
Date	Requested Delivery date	When the customers want the order delivered
	Loading date	When the forecasted date of loading
Loading details	Loading module	Codes for type of transportation used
	Loading type	codes for packing type, e.g: palletized, cartons, etc.
	Pallet type	Type of pallet used
Items ordered	Item	The number of Stock Keeping Unit (SKU)
	Material	Codes of Stock Keeping Unit (SKU)
	Quantity	The amount of Stock Keeping Unit (SKU) sold

Table 3. Sales Order Details

D. Transportation

Following the details presented on table, the transportation details should also be defined. The three important elements on transportations are: Delivery requested date, loading modules and loading types.

i.   *Delivery requested date*

This information is provided by customers depending on when they want to receive the products. However, there is a constraint in which the earliest loading time, the day on which the items would be prepared for shipping to be loaded which is more or less 4 days, this loading time added by the travel time to the destination point and clearance time, if applicable, would be used to estimate the proper delivery time. This delivery time is highly appreciated by Barilla and therefore, Barilla wants to ensure that every delivery promised can be fulfilled.

$$Delivery\ date = Loading\ date + Travel\ time$$

Loading module specifies the type of vehicles that would carry the goods from the plants to the customers. This information is important because the loading modules need to be able to perform a delivery in the best way possible. There are many types of loading modules that Barilla uses: A truck which can be a normal truck or a German truck or containers which can be a 40-ft, 20-ft or 40-ft high. A truck can further be specified whether it is loaded in full, which is a full-truck load (FTL) or a Less-than-truck load (LTL) which means that the truck is not saturated. The containers are different based on the volume and dimensions of the containers which can be selected by the customers based on their preference.

The selection of loading modules also mean flexibility, Barilla has developed a way to accommodate also smaller orders by specifying a single pallet place to be a loading module. This type of loading module specifies which pallet place is used for certain products of different customers within a truck or a container. This loading module is mainly used for VMI customers and to saturate better the transportation. It is important to note that the same loading modules might have different limits on number of pallets, volume and weight which is used by customers to consider which loading modules suit them better

iii.   Loading types

Loading type specifies how goods are put inside the loading modules. This loading type allows the communication to the warehouse on how a loading module would be loaded. Examples of loading types are on pallet, unpacked, on semi pallet, on fittainer, on 2 level, not overlapping pallet, or to customize a pallet + a layer. This loading types allow flexibility and help the warehouse to load according to the customer needs.

Once the order is registered in a correct manner, the order is passed to transportation planning which is indicated by the status of the order. When the status of order is **"transportation planning"**, it means that the order has been transferred to transportation planning as a temporary planning. To finalize the planning, the order needs to go through other two departments: **Transportation Planning Department (TP)** and **International Overseas Transportation Department (IOT).** These two departments perform almost similar tasks but are differentiated to handle the different complexity inside and outside Italy. TP now is charge of planning, assigning courier and monitoring shipments in Italy and to plan the shipments of other European countries. Only in Italy, TP is assisted by logistics department in contracting the freight forwarders, transportation company and couriers. In other companies in Europe, although the shipments are

planned by TP, IOT is in charge in contracting and assigning this outsourcing and monitoring it. For international overseas countries outside Europe, all the functions are performed by IOT. The segmentation of tasks is presented in the graph below:
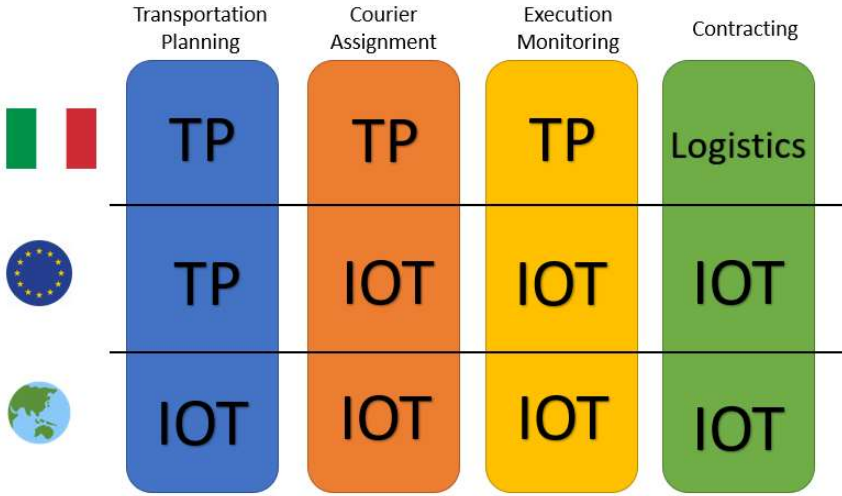
Figure 13. Responsibility Segmentation for Managing Shipping Documents

Transportation Planning	The main objective is to have fewest transportation possible by aggregating smaller orders into single loading modules. Ultimately, by having fewer transportation, Barilla can be more competitive in the price it is offering also since pasta has a low value density.
Courier Assignment	This function is performed by both TP and IOT department according to the area of the customers. The couriers which have been contracted are assigned 2 days within its deliveries to ensure their availability in performing the deliveries. Aside from the couriers, these departments also assign the freight forwarders, shipping companies and other companies which perform other modes of transportation which have been contracted previously.
Execution & monitoring	Both IOT and IOT are in charge of monitoring the shipments. KPIs are developed and are showed real-time in the headquarter. Some KPIs including the number of problems during loading, on-time delivery and delays.

Contracting	IOT and logistics department are also contracting the transportation companies to ensure their availability. The shortest contract would be an annual one in which the duration depends on the importance of the transportation companies.

Once the transportation has been planned completely, the status of the order would change that means that it is transfer to 3PL. This means that the planning has been accepted and cannot be changed.

E. Availability check/Order booking and material handling

The availability check consists in verifying the availability of an item at the loading date in order to confirm the request of the customer. In case of missing quantities (out of stock), the order is processed without the quantity. It is possible to manually reallocate the available quantities in order to change the automatic allocation.

In the Barilla model the availability check is usually managed after the final transportation planning, however its outcome can affect the transportation plan

- The document is then transmitted to the warehouse to start the picking phase.

- The outsourcing model for the warehouse management can be:

  - ✓ Internal: own warehouse management

  - ✓ External: 3pl management (the 3pl can be the same subject who is responsible of the transport phase)

- The picking phase and the loading phase show the real picked quantities; the material movements affect the accounting stock.

- The term «out of stock» is used when the shipped quantities do not correspond to the quantities confirmed in the delivery (out of stock at loading)

III.   Intelligent Modular Unit (IMU)

A. Introduction

Intelligent modular unit (IMU) is a name of a project developed by Barilla in producing Shelf-Ready Packaging (SRP). IMU or SRP is a solution designed to make a product that comes in a ready merchandised unit which is easy to identify, easy to open, can easily be put onto the shelf and disposed of, allowing an optimization of shelf replenishment and enhanced visibility [2]. In short, implementing IMU required changing the products secondary packaging which is originally used as an outer layer which protects the consumer unit during handling and transporting into a new secondary packaging which also goes to the shelf along with the products themselves. Using an ordinary secondary packaging means that, a handler would require to open it, take the products inside and refill the shelves. Meanwhile, using an IMU secondary packaging means that the handler can just perform an action, either by removing or folding some parts of the packaging and directly put it into the shelves together with the products, without discarding all of the secondary packaging. Some IMU types are given as follows:
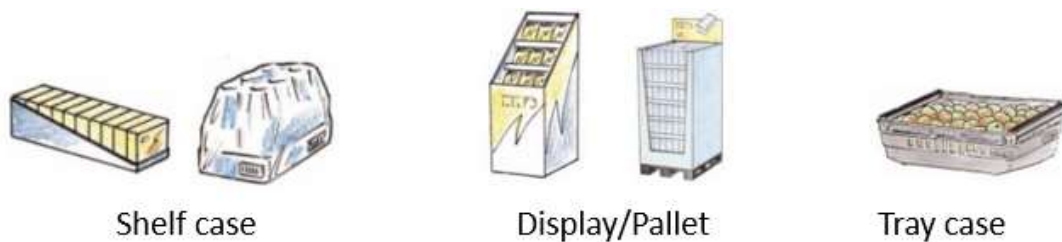
Figure 14. Types of Shelf Ready Packaging (SRP)

As for Barilla, the IMU would be developed for pasta products in three different launches. The first launch would be in April to June 2019 for the Bio pasta (both short and long cuts), the second would be for semolina pasta between June and September 2019 (both short and long cuts) and finally in 2020 for spoon pasta. These launches would be only for exports and not for Italy while the IMU implementation for Italy is delayed until March 2020. IMU implementation also comes with uniformity of pallet types to pallet European with 1200 mm or P120. This uniformity of pallet use is another potential benefit for Barilla which comes from IMU, mainly where on-shelf space is low for Barilla, and Barilla can now send more varieties of items to its customers.

B. Design Key Performance Indicators (KPI)

To fulfill its purposes, the SRP should be designed to fit into 5 categories of design. According to ECR-Europe, the categories are: Easy Shop, Easy Open, Easy Shelf, Easy Identification, and Easy Dispose. These 5 categories came with criteria that needs to be fulfilled which although are not binding, they help companies in designing their SRP to be useful.

i. Easy Shop

The implementation of SRP Packaging should **increase visibility to consumers** as buying decisions are made in split seconds. It should **enhance the appearance** of the products which means that the SRP should make a positive impact on the shopping experience of consumer by allowing the customer to easily identify the location of the items and have multiple varieties to choose from. Finally, **easy to be picked or customer-friendly** which means that the additional packaging which goes to the shelves should not obstruct the consumers from taking an item from the shelf**.** The design of the primary packaging should consider the consumers which would pick these items and does not create any difficulties.

ii. Easy Open

Since SRP may not be implemented by a single company only, but also by other players who supply their goods to retail stores, it may create confusion as to open each pack as the designs would absolutely be different from one product to another. The producer should **provide simple instructions** in which to dispatch its items and design the SRP packaging in such a way that makes it **easy and safe to handled**. The latter means that the SRP packaging should easily be opened without additional use of sharp tools such as knives or scissors, should have the quality to sustain the weight of its contents while being handled, and once opened, to not leave sharp edges.

iii. Easy Shelf

Easy shelf refers to the ability of the packaging **to have stability** while sustaining other products which may be stacked on it. The design of the packaging also needs to **respect the standard shelf size and optimize space.** This would avoid further difficulties in refilling the shelves. Finally, **the design must offer multiple facings** to give flexibility in managing the shelves.

iv. Easy Identification

The additional space provided by SRP package should be utilized **to increase the product's visual identification**, allowing handler to recognize the location of the products and assist in moving the goods. In this case, a lot of SRP trade units are to be with big window, allowing the handler to see the content of the trade units without opening them. For end consumers, the easy identification increases the distinguishability of the items and differ them from those of competitors. While the front part is filled with information that will attract consumers, the sides can be utilized to **provide better information to the seller** about how the products should be handled and stored, the contents and other important information. This KPI helps to emphasize the power of the branding to the products using color, fonts or symbols which are associated with the product.

Additional secondary packaging may result in more empty boxes occupying the warehouse of the retailers. The SRP packaging should be **easy to be collapsed** and **respect the legislation**. Not all SRP packaging would be returnable, therefore, the producer should ensure that the materials used to produce it may be recycled and provide information on the packaging regarding this activity.
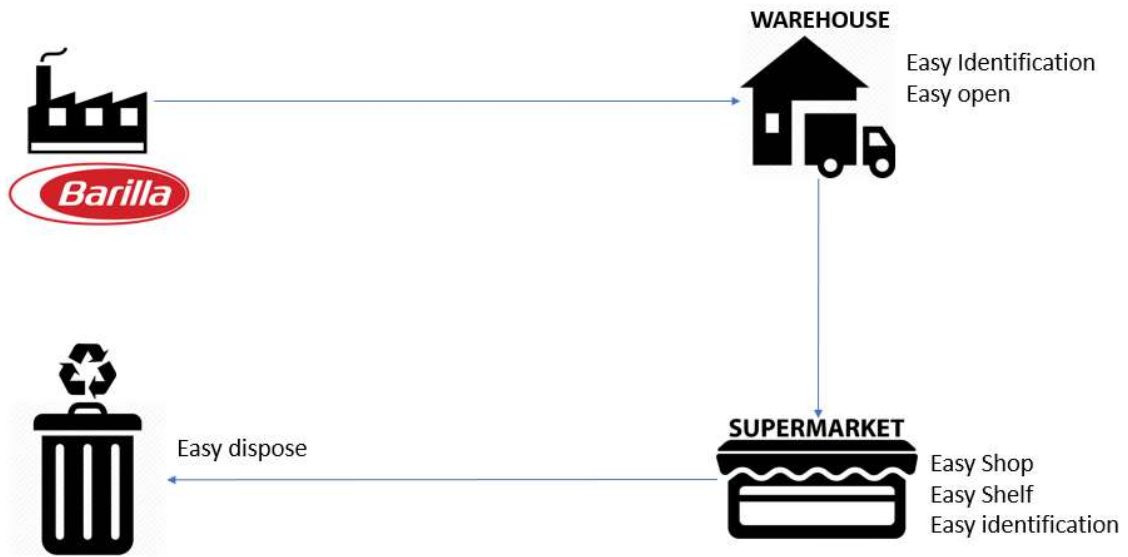
Figure 15. Impact of KPIs in Supply Chain

In the case of IMU projects, they are designed to have these requirements of SRP. The first three criteria: Easy identifications, Easy open and Easy Dispose are mainly elements that would improve the warehouse performance of both Barilla and first-level customers. For the Easy Identification, Barilla color the trays of product with its trademarked blue color, its logo and a slogan "Masters of Pasta" with a famous tennis player as the spokesperson giving a distinctive appearance compared with its competitors. For the warehouse managers or handlers, the SRP unit can be equipped with a window to see the products inside without opening them. For the Easy Open, the IMU trade units consist of 2 parts which are glued together instead of taped. This allows an easier open compared with the old American boxes although it eventually means harder to be re-closed after being opened. Meanwhile, the material of the IMU boxes would still mainly cardboard which is easy to be folded and disposed. Easy shelf and Easy shop would create benefits such as increasing the varieties of product sold which is a benefit for both Barilla and the first-level customer shop managers mainly where on-shelf space is low for Barilla's products. For these shop managers also, it is easier to replenish the shelves due to the modularity of IMU while for both the shops and Barilla, more varieties can be offered and sold to consumers.

The implementation of IMU packaging would affect several aspects of Barilla's operation. Since IMU packaging will come in three different waves, **the first problem is when the production needs to adjust with this change and to make sure that all stocks of the old products have been sold.** Barilla needs to respect the timing of switch which is based on the installation of the new repacking machines. During these times, the production capacity of IMU grows while the production capacity of old American case decreases. The remaining stock between these two should be used to satisfy the demand of the market which usually happen during a trade window or promotion. **The second problem is during the execution.** During execution, the forecast might be disregarded, the productions may not be as expected or more than expected and finally in communicating the customers about when to switch, as once the switch has taken place, the customers would not accept the previous versions. Thus, selecting the right time to send IMU items must be managed correctly with all customers by considering the switch timing, the stock level and the customer's readiness to accept the new goods.

IV. IMU Implementation

This chapter mainly explains the quantitative analysis of the elements Easy Shop and Easy Shelf. The main criteria analyzed for Easy Shop is space optimization while for Easy Shelf is the enhancing of appearance and being customer friendly. The calculation regarding the space optimization would be presented from point B to G and the enhancing of appearance and customer and being customer-friendly which relates to the repacking of items would be presented in point H. Finally, an example on the situation on customer warehouse during IMU switch period is presented on point I.

A. Analysis Background

The background of the analysis comes from the fact that Barilla will try to uniform the dimensions of its products and put them on the same pallet, which is the European Standard Pallet 120 (P120), a pallet with height of 1200 mm. Although being a standard pallet, some other countries might not use it prior to IMU due to local regulations or to harness possibilities. For example, in Germany P105, a name for Pallet with 1050 mm height, is used and for Italy, P160, a name a pallet with 1600 height, is used. Since most of the retailers now have started to demand Barilla to uniform the dimensions and adopt shelf-ready packaging, it became clear that Barilla should start applying this change. Besides dimension change, some large customers in some countries have always preferred a shelf-ready packaging (SRP) instead of the normal box to minimize aisle congestion, reduce out of stock and reduce replenishment time. Since these locally managed SRP requires subcontracting re-packers,

stopping these local repack by having Shelf-ready packaged items produced centrally may be a source of cost optimization. The name IMU itself, which is actually how the project is initially named by board of directors, is an abbreviation from Intelligent Modular Unit which means that Barilla's product will receive dimension changes to be more similar to one another and to fit better P120. Before IMU, the old products may be created in different years and the modularity among items was not an objective.

The changes observed on the IMU versions are the dimension change and the weight change. Combined, these two values may become a specific weight or kg/M3. The analysis would mainly calculate how the new IMU dimensions would change the number of trade units per pallet and eventually, the total weight per pallet. Since the cost rates are in the base of one pallet place, the higher specific weight on a pallet place, the less pallet would be resulted from the same weight turnover and the more optimized the space-use will be. The use of pallet as a starting point is due to 88% of Barilla's items are delivered on pallets while the other 9% are using containers without pallet. Although the items sent by containers do not use the pallet, it does not mean that the items are stored randomly. These items sent by containers were before stored on pallet and wrapped. Only when they are to be loaded on a container, Barilla removes the pallet keeping the dimensions loaded as if it was palleted. Thus, the pallet saturation would also affect the container saturation.

As a conclusion, if by using IMU boxes, Barilla can send less pallet, the project is evaluated with cost savings while if the result is the opposite, it means Barilla is making an investment to fulfill the customers' need. To monetize the pallet difference, cost rates are taken from the previous transaction, on average how much Barilla had paid to send a pallet:

- o From a plant in a specific country to a country of destination
- o Using a certain type of loading module
- o In a specific time
- o Of a certain product

Finally, the pallet difference multiplied with the cost rates would be used to calculate **transportation cost** and **storage cost.**

The third and last cost to be considered would be **repacking activities**. Some countries had previously repacked their goods before the arrival of IMU. Repacking activities are when consumer units are taken out of their original packaging and repacked with new packaging which suit the requirements. There are 4 categories of repacking activities: creation of Local IMU/SRP, display unit,

stickered products or multipacks. The details would be presented in section H. Stops of Repacking Activities.

If the repacking activities can be stopped after the arrival of IMU versions, it is considered as a saving. The saving is a function of the local repacking and material cost and the turnover of that respective item in the certain period.

B.   IMU Turnover Analysis

Not all Barilla products would receive IMU versions. IMU versions would be developed only for products within category "Dry Semolina Pasta" and exclusively for pasta sold under "Barilla" brand. Under this group also, not all pasta would receive an IMU version. To understand the scope of the IMU calculation, it is important to present the turnover with IMU versions presented for each region. Segmentation based on regions is important because when an overall value is used for a large coverage, most of time it may be deceiving.

When the results are presented, all the values would be presented in % for the sake of confidentiality and during the calculation, the turnover considered is the most recent 12 months. 12 months is taken as the duration of the analysis since it is impossible to take more years back to create a trend since the product lifecycles are very various. Many of the items that were sold are not sold anymore in 2019 and if considered, would affect the data since total values are important in calculating percentage.

I.   AAA (Africa, Asia and Australasia)

%turnover of items with IMU to respective countries turnover

%IMU turnover compared to each region

AFRICA 5,1%
AUSTRALASIA 30,7%
CHINA 5,8%
GCC 12,3%
ISRAEL 15,6%
JAPAN 5,7%
LEBANON 13,2%
OTHER ASIA 3,6%
OTHER MIDDLE EAST 1,2%
SOUTH EAST ASIA 6,5%
TURKEY 0,2%
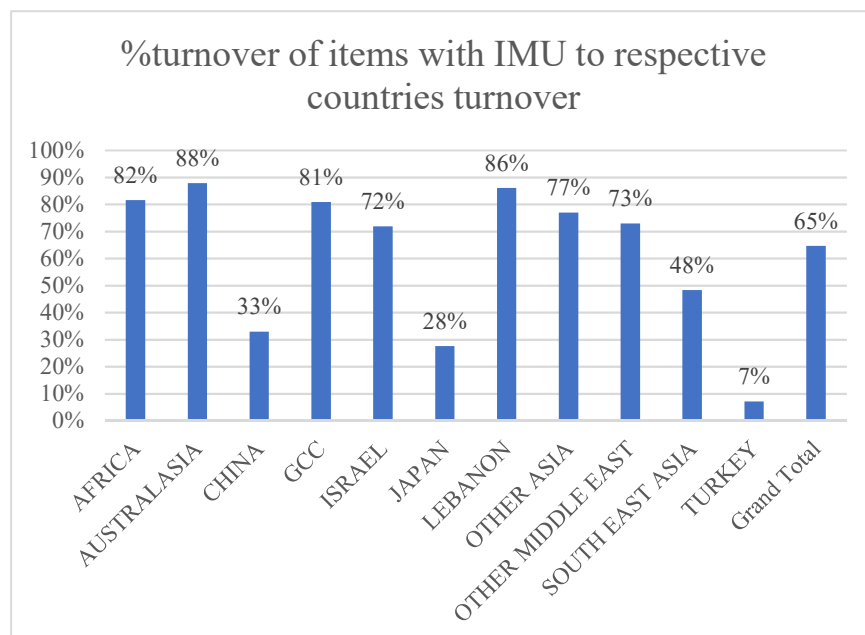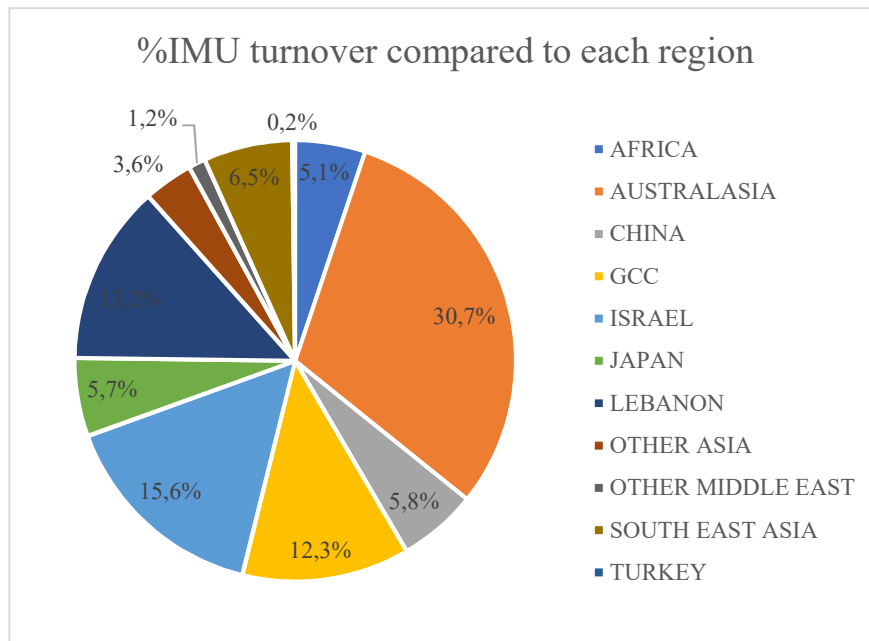
Figure 16. %Turnover IMU in AAA against total turnover (bar), %Turnover compared among markets (pie)

The region AAA covers the Asian, Australian and African markets as presented in Figure 16. Overall, AAA would have 49% of item sold changed to IMU. This 49% of the item covers 65% of the total AAA turnover for the last 12 months. The markets with largest % of IMU change respective to their initial turnover are Australasia with 88%, Lebanon with 86% and finally Africa 82%. However, when compared with one another, the markets with highest turnover affected by IMU are Australasia, Israel and Japan.

II.   Western Europe

%IMU items turnover

BELGIUM 81%
FRANCE 79%
NETHERLAND 74%
PORTUGAL 90%
SPAIN 91%
UK & IRELAND 9%
TOTAL 78%
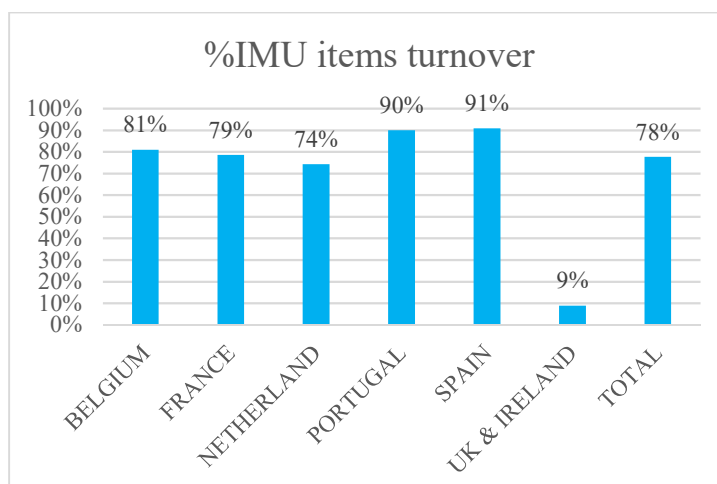
Figure 17. %Turnover IMU in Western Europe against total turnover (bar), %Turnover compared among markets (pie)

In Western Europe covers the analysis of the markets mentioned in Figure 17. Among these markets, Spain has the highest percentage of turnover with IMU compared with its total turnover, 91%. In the second place and third place are Portugal with 90% and Belgium with 81%; respectively. As an overall, 45.3% of the SKU sold in Western Europe will change to IMU. This 45.3% of SKU covers in total 78% of the total turnover in the last 12 months. While not being one among 3 countries with highest %turnover compared with their total market turnover, France has most of the turnover which would change to IMU. This is due to a contrast market size between France and the others. From the 78% total turnover with IMU, 84.7% of it comes from France. This would make France an important country which will see the outcome of the analysis in Western Europe.

III.   Central Europe

27

Distribution of IMU turnovers
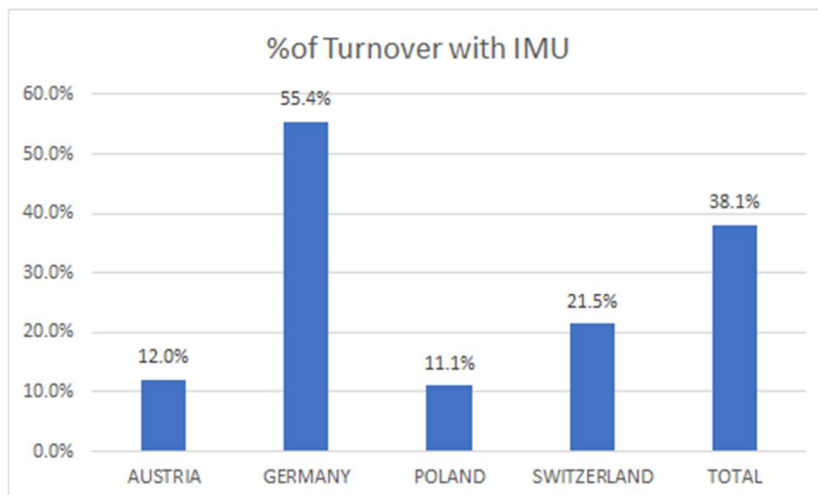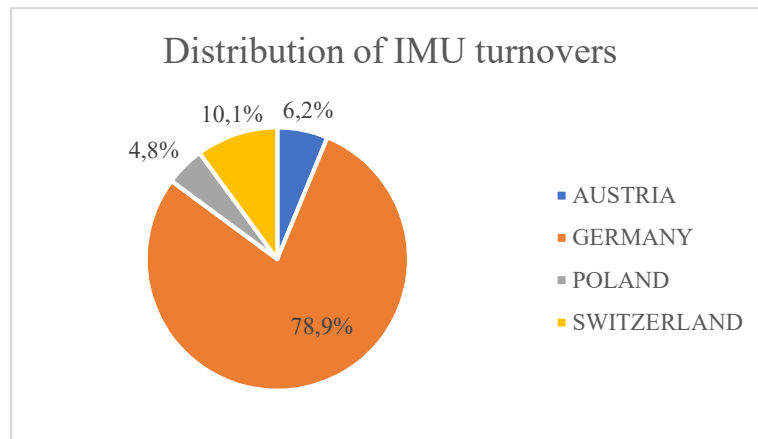
Figure 18. %Turnover IMU in Central Europe against total turnover (bar), %Turnover compared among markets (pie)

In Central Europe, the markets involved are as mentioned in Figure 18: Germany, Austria, Poland and Switzerland. Among these markets, Germany has the highest percentage of turnover with IMU compared with its total turnover with 55.4% while Poland has the lowest with 11.1%. When compared with one another in the same region, 78.9% of the total turnover change in Central Europe is also from Germany while the other 10% is in Switzerland, 6.2% in Austria and finally 4.8% in Poland. This dominant percentage would explain that not only does Germany has the highest IMU turnover compared with its initial turnover, it also has the highest IMU turnover compared with its total region turnover. Overall, Central Europe would have 38.1% of its turnover switched to IMU with Germany being the dominant country in this region.

IV. Great Eastern Europe
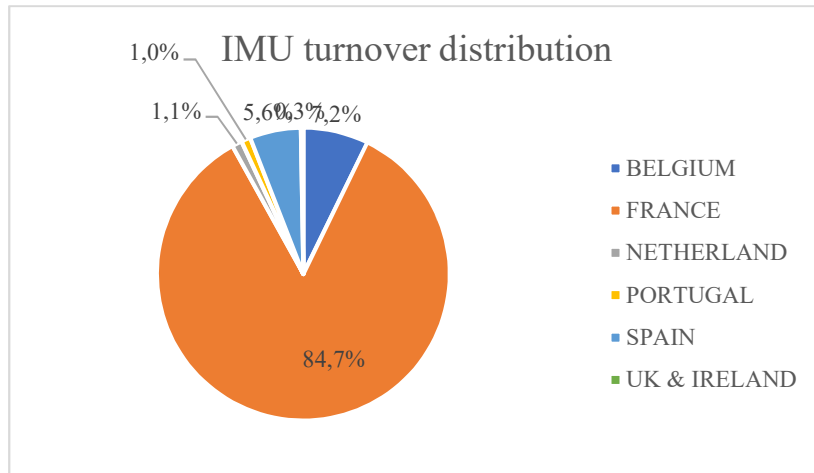
%of IMU Turnover distribution
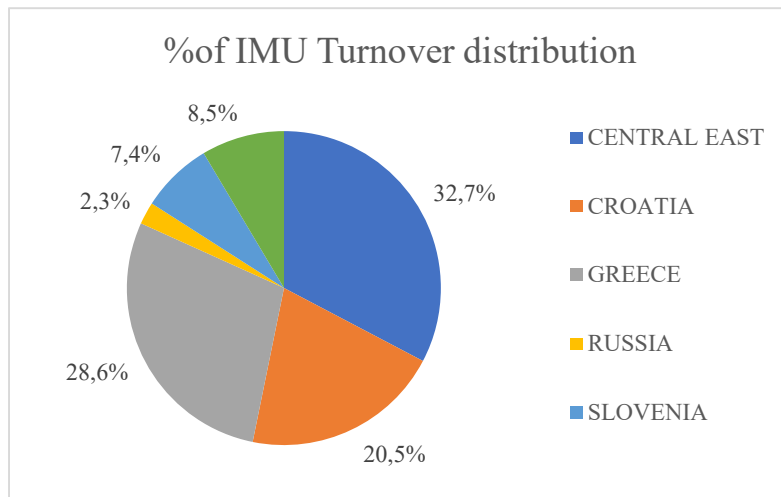
Figure 19 %Turnover IMU in Great Eastern Europe against total turnover (bar), %Turnover compared among markets (pie)

In Great Eastern Europe, the markets covered are as mentioned on Figure 19. In Great Eastern Europe, 37% of the SKU would be affected by IMU and this 37% covers the total of 61% of the total 12 months turnover in the region. In the turnover point of view, South East Europe market and Croatia market almost changed their entire product with IMU with 96% and 94% of turnover affected in respect to their total local turnovers. Overall, IMU items turnover covers 61% of the turnover in Great Eastern Europe. Meanwhile, when this 61% is inspected further, Central East market would have the highest turnover change covering 32.7%, Greece with 28.6% and finally Croatia with 20.5%. Another key point to see is that no items in Other Russia market would change and very few in Russian market.
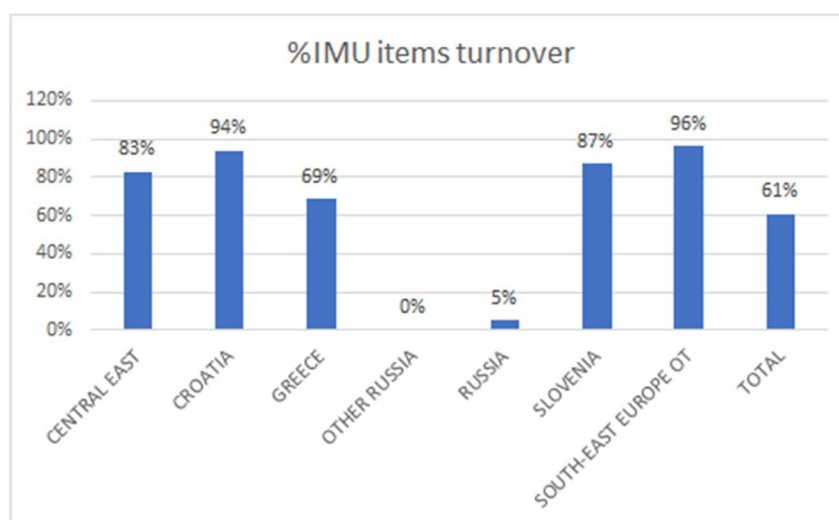
V.   Northern Europe

%IMU items turnover
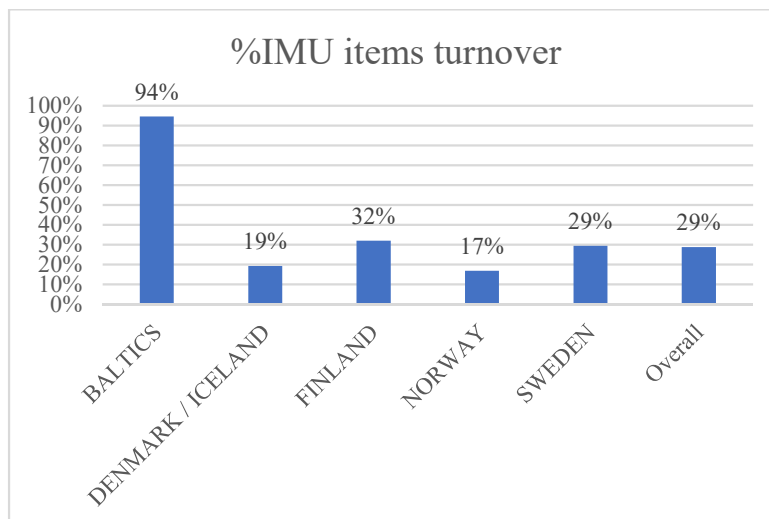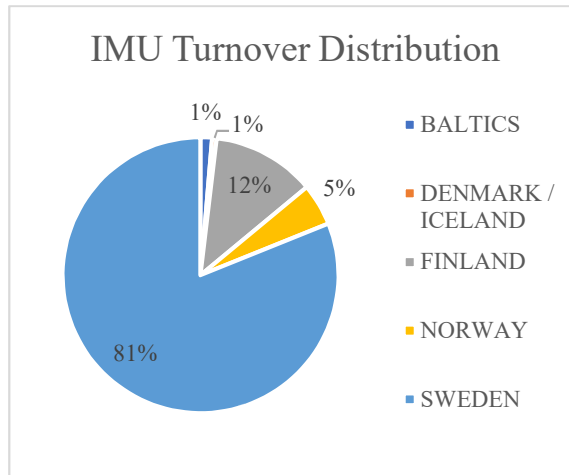
Figure 20. %Turnover IMU in Northern Europe against total turnover (bar), %Turnover compared among markets (pie)

The markets covered by Northern Europe region are presented on Figure 20. In Northern Europe, 55% of the SKUs sold there would receive an IMU version by 2019. These 55% covers 29% of the region's latest 12 months turnover. Among these markets, Baltics market receives the most change compared with its own total turnover with 94% of its turnover will become IMU in 2019. Meanwhile, other markets seem to be affected moderately at 20 to 30%. Despite having changed almost entirely, the Baltics turnover is the smallest compared with other markets. Hence, when compared with one another, Baltics market only covers 1% of the 29% overall turnover change, leaving Sweden as the most dominant market with 81% of the 29% overall turnover change despite having only 29% of market turnover affected by IMU. This means that the IMU change in Sweden would be the most impactful in Northern Europe region.

VI.   America
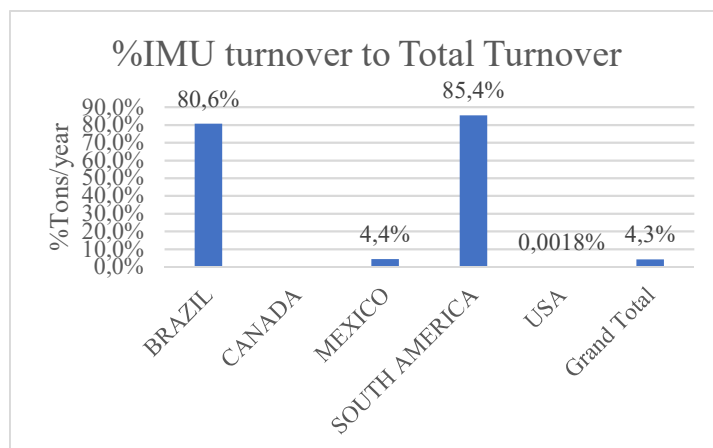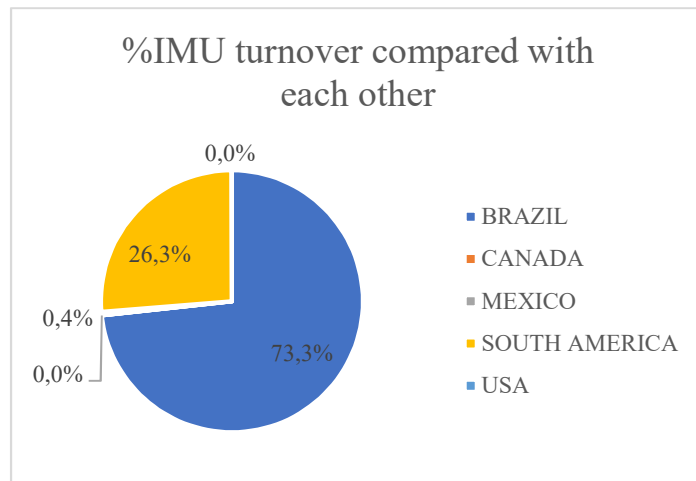
Figure 21. %Turnover IMU in America against total turnover (bar), %Turnover compared among markets (pie)

Among other regions, America region receives the smallest change to IMU. In 2019, the change would only cover 4.3% of the last 12 months turnover with only 18% of the SKU sold in America will receive an IMU version. The dominant markets in America are South America and Brazil while the others receive very small change or not at all for Canada. When compared against each other, Brazil covers the highest turnover change with 73.3% of the total 4.3% which makes Brazil as the most important market to consider while analyzing the effect of the IMU change.

C.   IMU Case Reduction Analysis

This section would present the number of case reduction of items with IMU versions. The case count is reduced due to the process of increasing the modularity of trade units. To find the overall case reduction, a weighted average is used. A weighted average is suitable than a simple average because the number of cases may or may not change for items involved in IMU. There should be no problem when the IMU version does not include a change in number of cases, but when there is a change for an item, the impact of the change would not be equal to the average value because the difference in quantity sold. For example, some items may receive a lot of case reduction, but since we sold really few of them, this reduction may not make a lot of influence to the overall average of case reduction. Hence, the change of every item is weighted by its relative turnover divided by the total turnover of the market. The weighted components are summed to obtain the weighted average of a market and presented in Table 4 below.

Region	%reduction/region	%OVERALL REDUCTION
AAA	12,1%	
America	9,2%	
Central Europe	4,9%	
Great Eastern Europe	8,2%	**7,6%***
Northern Europe	12,8%	
Western Europe	7,6%	
	TOTAL	

Table 4. Overall case reduction of Region

To find a weighted average of a region, the weighted average of markets inside the regions are simply added.

$$Market\ case\ change = \sum_{x=1}^{n} \frac{item_x\ turnover\ \left[\frac{tons}{year}\right]}{Market\ turnover\ \left[\frac{tons}{year}\right]} * \Delta item_x\ case\ \left[\frac{case}{TU}\right]$$

$$Total\ Region\ case\ change = \sum_{x=1}^{n} market_x$$

Equation 1. Calculation of Case Change Analysis

I.   AAA (Africa, Asia, Australasia)

Figure 22. %average case reduction/average initial cases in AAA (bar), contributions each market on total reduction in a region (pie)

Less cases% compared to each other AAA
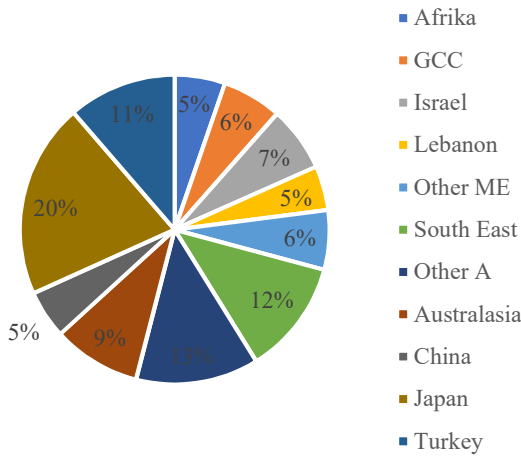
All markets in region AAA have reduced consumer units per trade units. The markets with most reduction compared with their initial cases are Japan with 31%, Turkey with 20% and finally South East Asia and Other Asia with 17%. As an overall, the weighted average of reduction is 12.1%. When compared with one another, the highest contributors of this reduction are Japan, other Asia and South East Asia. This means that although items in Turkey receive a high reduction in cases, the turnovers are low compared with other markets, stopping it from influencing overall average. Japan is the most affected countries in terms of case reduction with 20% reduction compared with its initial average number of cases and covering 20% of total case reduction in AAA.

II.   Western Europe

Figure 23. %average case reduction/average initial cases in Western Europe (bar), contributions each market on total reduction in a region (pie)

%less cases compared to other markets Western Europe

All markets in Western Europe also receive a reduction of cases per trade units. These markets receive moderate reductions, with France having the most reduction of 11% and UK & Ireland the lowest with just 2%. On the average, Western Europe receives 7.6% case reduction per trade unit from IMU. When compared against one another, These markets share an almost equal

contribution to the total region reduction at around 20% each.

III.   Central Europe
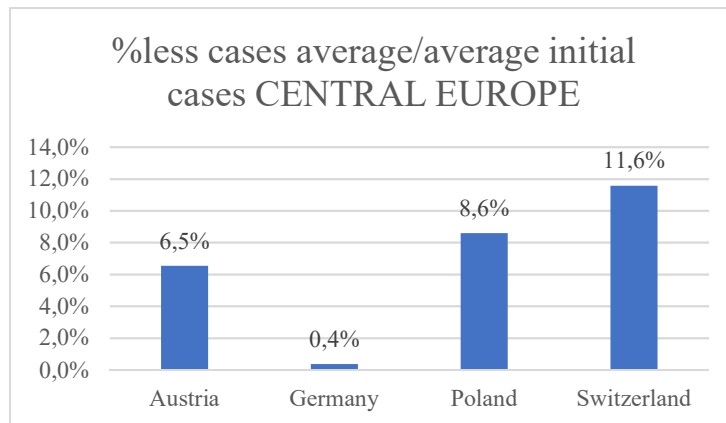
Figure 24.%average case reduction/average initial cases in Central Europe (bar), contributions each market on total reduction in a region (pie)
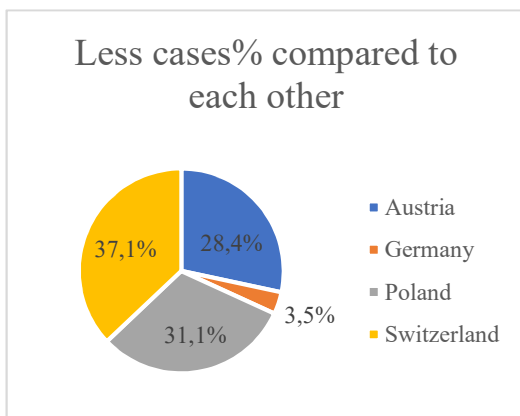
All markets under Central Europe region receive reduction in cases per trade units. The market with highest reduction is Switzerland with an average of 11.6% of reduction while the lowest is Germany with just 0.4% reduction. Overall, the SKUs in central Europe region receive the less reduction compared with other regions with a weighted average value of 4.9%. Out of this 4.9%, Switzerland contributes the most by occupying 37.1% of the total case reduction.
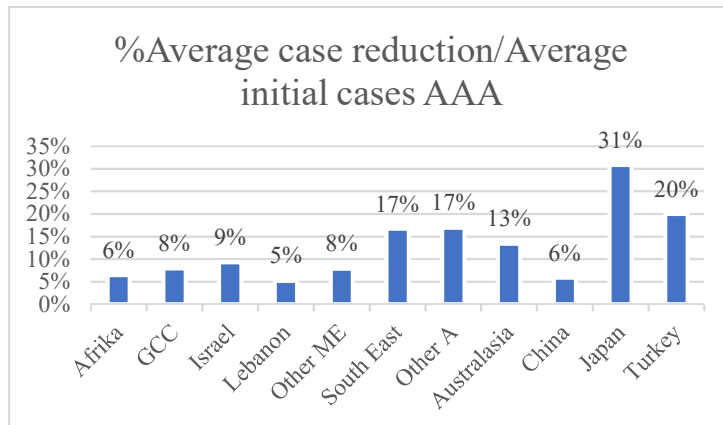
IV.   Great Eastern Europe

Figure 25. %average case reduction/average initial cases in Great Easter Europe (bar), contributions each market on total reduction in a region (pie)

%less cases compared to other markets Great Eastern Europe

- Central east
- Croatia
- Greece
- Slovenia
- South Adriatik
- South-east Europe others
- Russia
- Other Russia

17,1% · 3,8% · 10,5% · 14,1% · 15,5% · 9,2% · 15,5% · 14,3%

All markets in Great Eastern Europe have less cases per trade units following IMU switch. The reductions are at around 10% for almost all the markets except Russia, South-East Europe and Greece which are at 3%, 6.1% and 5.5%; respectively. Meanwhile, when compared to one another, these markets contribute to the equal amount to the total case reductions in the region except for Russia which only contributes 3.8% to the overall reduction. Overall, the items sold in Great Eastern Region would have 8.2% total reduction of cases.

V.   Northern Europe

%less cases average/average initial cases Northern Europe

Baltics 10%, Denmark/Iceland 13%, Finland 8%, Norway 18%, Sweden 16%
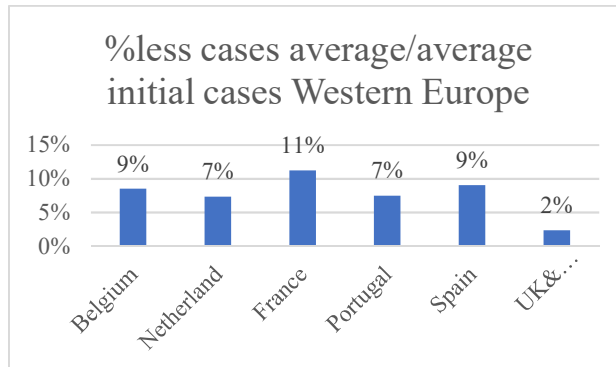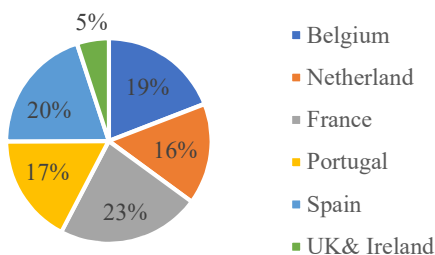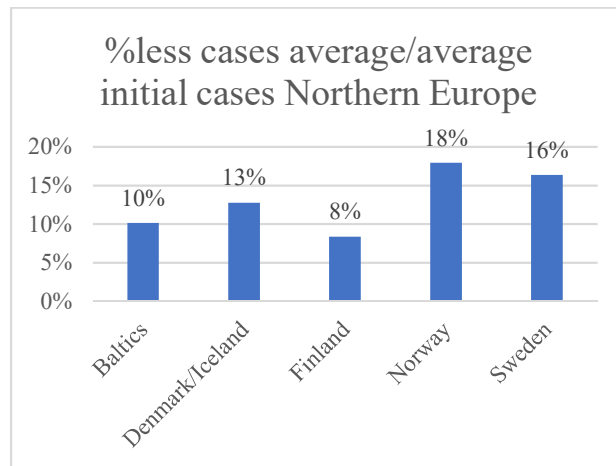
Figure 26.%average case reduction/average initial cases in Northern Europe (bar), contributions each market on total reduction in a region (pie)

%less cases compared to other markets Northern Europe

- Baltics
- Denmark/Iceland
- Finland
- Norway
- Sweden

17% · 21% · 14% · 25% · 24%
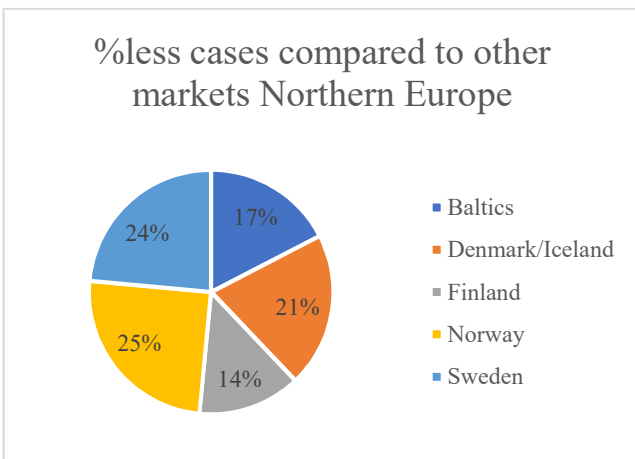
Markets in Northern Europe have less cases per trade units when IMU versions arrive. The most reduction is at Norway which averaged at 18% of its initial cases while the lowest is in Finland which averaged at 8% of its initial cases. When compared to one another, Northern Europe region has a total of 12.8% reduction, the most compared with other regions. Norway

contributes the most to this total, having 25% of the total region case reduction.

VI.   America

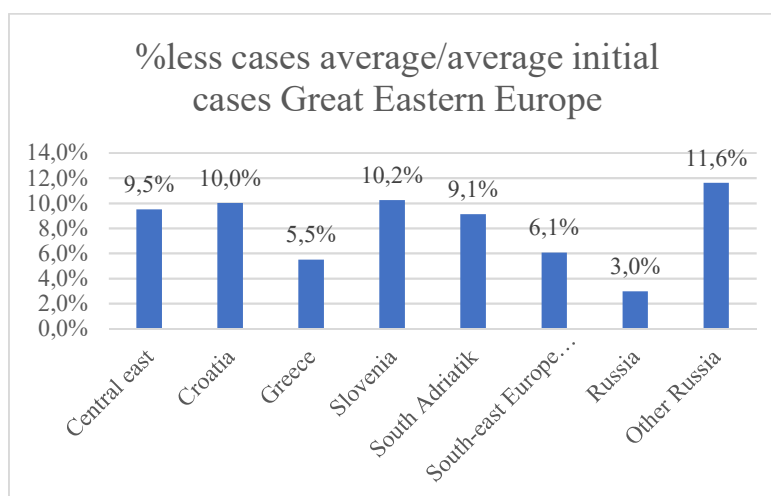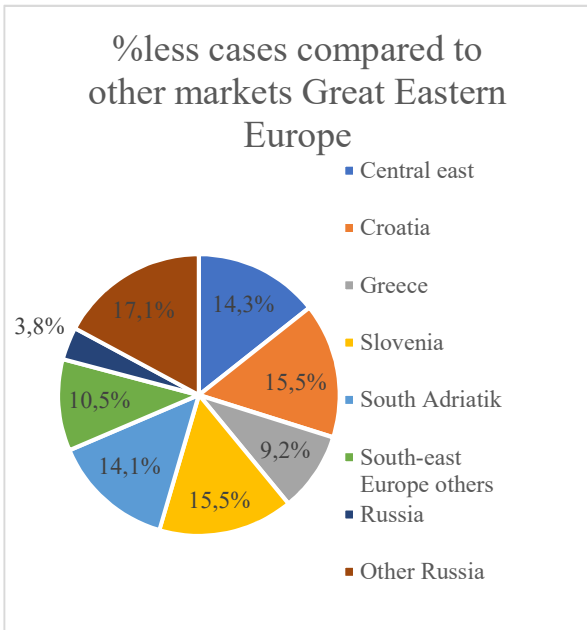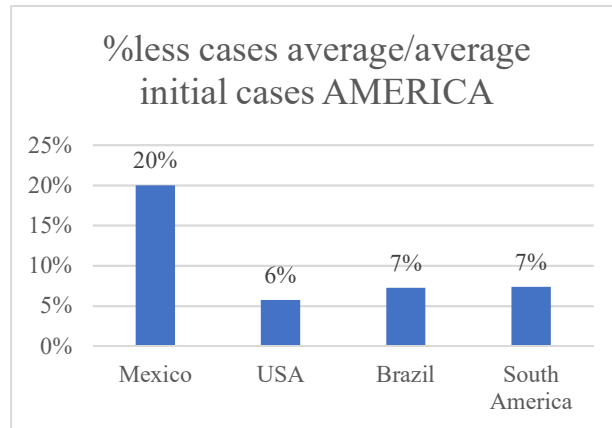*Figure 27. %average case reduction/average initial cases in America (bar), contributions each market on total reduction in a region (pie)*
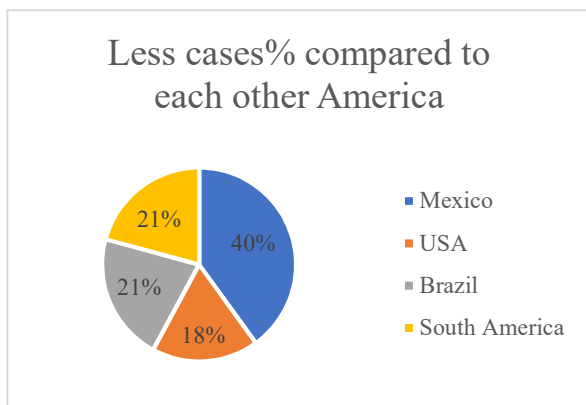
The last region, America, would also have less cases once IMU arrive. The total average reduction of the region is 9.2% in which 40% of it comes from Mexico while the other 60% is shared equally among USA, Brazil, and South America.

D.   IMU Dimension Saturation Analysis

The case reduction analysis shows that all items in all regions receive case reduction. This chapter compares the old and IMU dimension saturation to understand how the saturation changes after the consumer units are reduced. By obtaining modularity, it is expected that Barilla would be able to saturate better the pallet and thus improve its logistics performance. The old versions have three different trade unit orientations which depends on which orientation would fit more cases in each layer. The two trade unit orientations are described according to the formula below:

$$A: \left\{ \frac{Pallet\ length}{Trade\ unit\ length} ; \frac{Pallet\ width}{Trade\ unit\ width} \right\}$$

$$B: \left\{ \frac{Pallet\ length}{Trade\ unit\ width} ; \frac{Pallet\ width}{Trade\ unit\ length} \right\}$$

Equation 2. Trade unit Orientation Formula

Meanwhile, the third one consists of items with special arrangements. This special arrangement is made because the products could not fully saturate a pallet if all the trade units have the same orientation. Consequently, these items have multiple orientations of trade units in a pallet and the number of trade units per pallet length and pallet width cannot be obtained from calculation, but by extracting the information on SAP as shown on picture below

$$C: \{\#trade\ units\ in\ SAP; \#trade\ units\ in\ SAP\}$$
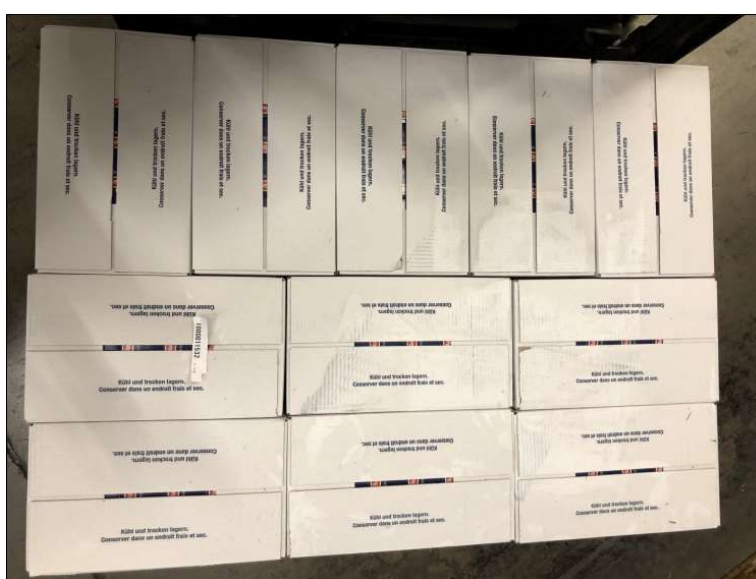
Figure 28. Pallet with 2-oriented trade units

Unlike the old versions, all the IMU new versions would only have one trade unit orientation which is facing forward or orientation A. This change in trade unit orientation is important because the IMU versions would directly go into shelves with the trays. Thus, all the cases inside the trade units should be ready to be picked by customers and facing customers. Another important point is for the long cut pasta since they would receive case orientation change as well. These long cut pastas used to be placed vertically inside the old box while with the IMU versions the long cut would be placed horizontally. This change in case orientation along with the change of case number would affect the dimensions. Since IMU versions should be designed to be modular so that they could fit the pallet better, it is important to understand whether they do saturate the dimensions better than the previous versions. Trade unit orientation must not be confused with consumer unit orientation. The trade unit orientation is how trade units are arranged respective to a pallet while consumer unit orientation is how cases are arranged respective to a trade unit. Most long cuts pasta would receive a

change in consumer unit orientation from vertical to horizontal despite their initial trade unit orientation.

The saturations would be measured on the length, height and width for every structural type. The structural types depend on what items are available in each market which are long cuts, short cuts, repack short, repack long and repack mixed. The items in repack mixed are yet to receive the specifications and are excluded from the calculation. The segmentation of the structural type is used in order the ease the analysis since the considerations on dimension change are similar for each. The formula used for dimension saturations are

$$Length: \frac{ROUNDDOWN\left(\frac{pallet\ length}{Trade\ unit\ length};0\right)}{\left(\frac{pallet\ length}{Trade\ unit\ length}\right)}$$

$$Height: \frac{ROUNDDOWN\left(\frac{pallet\ height}{Trade\ unit\ height};0\right)}{\left(\frac{pallet\ height}{Trade\ unit\ height}\right)}$$

$$Width: \frac{ROUNDDOWN\left(\frac{pallet\ width}{Trade\ unit\ width};0\right)}{\left(\frac{pallet\ width}{Trade\ unit\ width}\right)}$$

Equation 3. %Dimension Saturation Formula

I. AAA (Africa, Asia, Australasia)

A. Long cuts Pasta
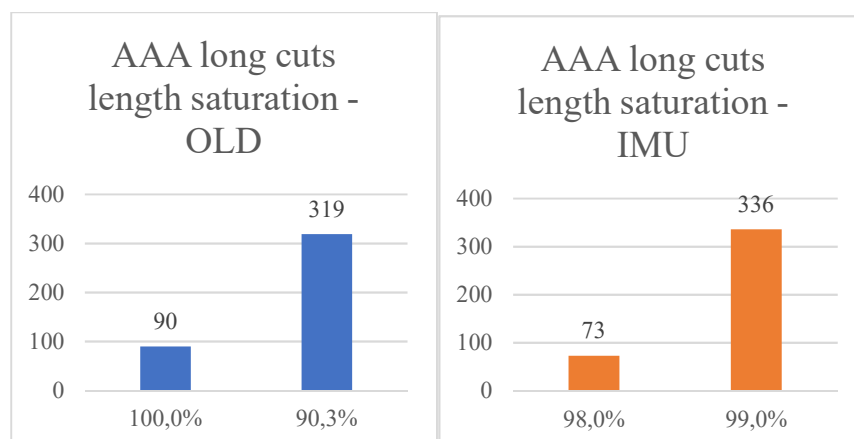
Figure 29. Long cuts Length Saturation AAA

Some long cuts item already had 100% saturation but mostly only had 90.3%. This saturation increases to either 98% or 99% after IMU switch which means that with IMU, all the items in AAA

have fully saturated the length. Due to the change of case orientation from vertical to horizontal, the IMU trade units of long cut pasta typically have lower height and shorter length regardless of the initial orientation of the cases. All IMU trade units in AAA region have reduced lengths to 300 mm which is a multiple of the pallet length and now there are more layers of item in IMU versions with an increase saturation from 80% to 100%.
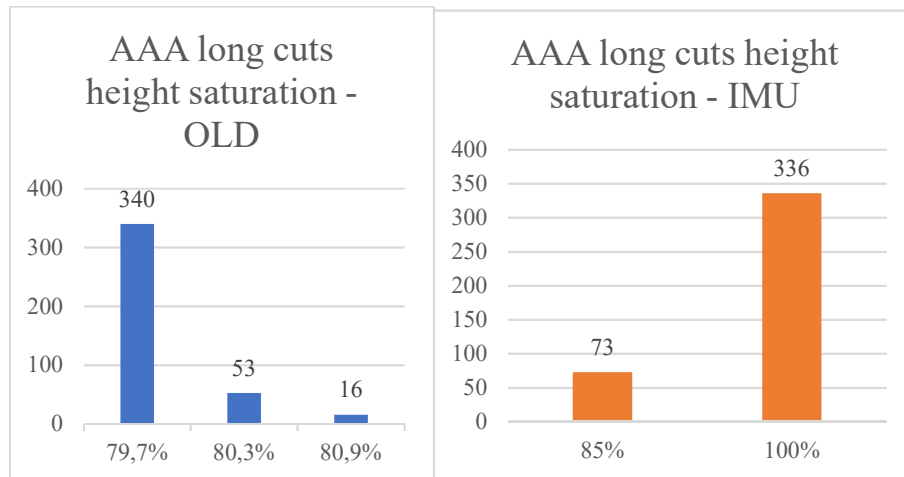
Figure 30. Long cuts Height Saturation AAA

The reduced length and height are compensated by the width. The widths are now increased to 400 mm which is the multiple of 800. Since most of the previous widths were already the multiple, increasing the width does not change the saturation although the variances are reduced and most of the items are better saturated with IMU versions.
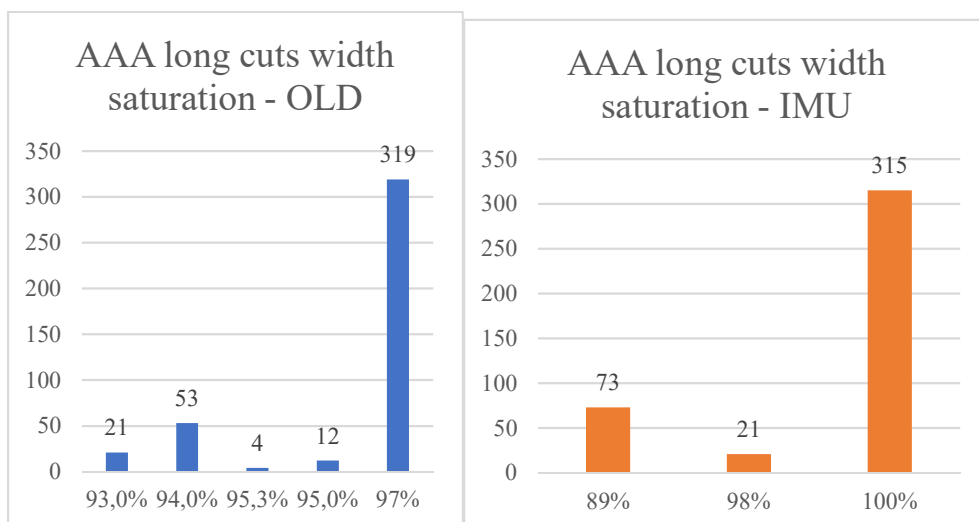
Figure 31. Long cuts Width Saturation AAA

The short cut pastas in AAA region also received an increase in saturation. Just like the long cuts, the lengths are being reduced from 400 mm to 300 mm. Since both dimensions are the multiple of pallet length, no increase in dimension saturations after the switch as pictured on the graph, only a minor change.
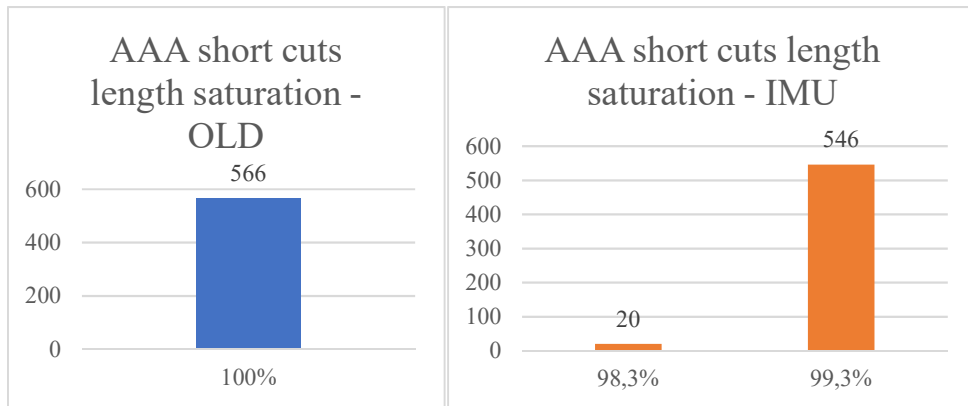
Figure 32. Short Cuts Length Saturation AAA

The reduced length is compensated by the additional height. Adding the height of the short cut boxes does not add more layers, it just saturates the net height of the pallet. The saturation of height increases from 88.6% to 97% while the variances drops meaning that the heights are more modular.
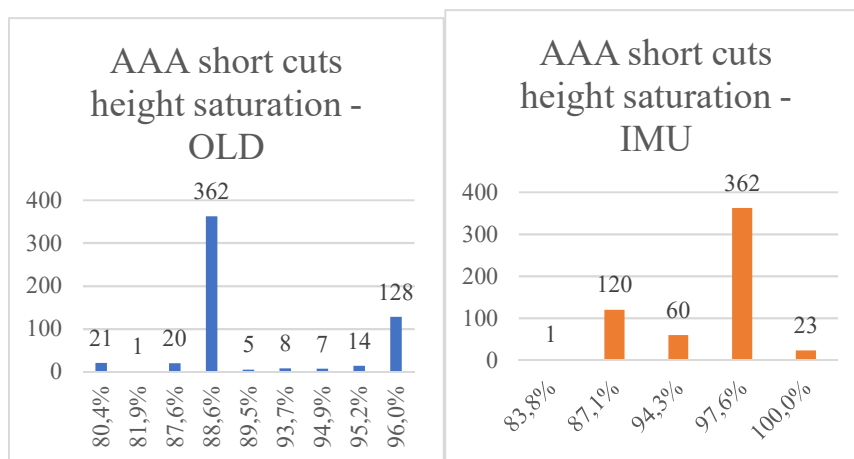
Figure 33. Short Cuts Height Saturation AAA

Finally, the widths of the short cuts are mostly already 400 mm, the same as the IMU widths. Other items with shorter widths are turned into 400 mm to increase the modularity. Since both dimensions are multiples of 800, the saturations do not change.
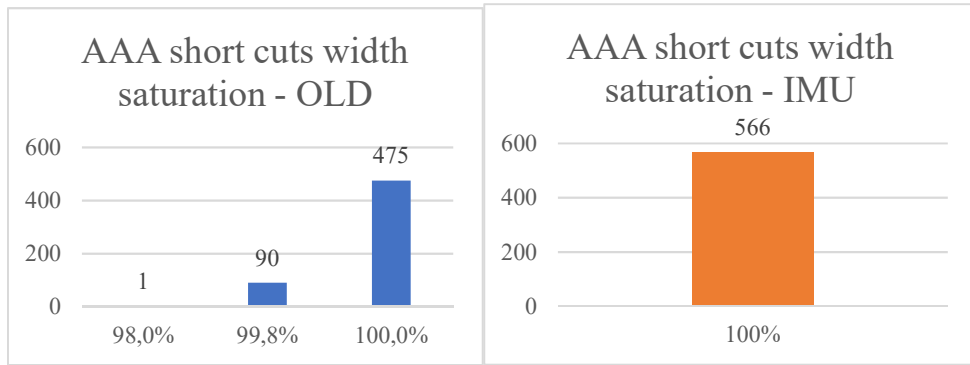
Figure 34. Short Cuts Width Saturation AAA

II. Western Europe

A. Long cuts Pasta
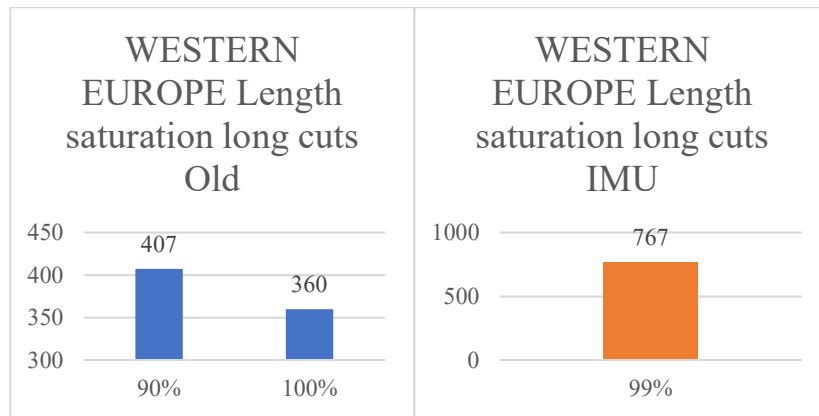
Figure 35. Long Cuts Length Saturation Western Europe

All trade units of long cut pastas in Western Europe receive a single dimension which is 300 mm. This new dimension increases the saturations from mostly 90% to a single value of 99% with no variance. The change of case orientation from vertical to horizontal also causes the height to be reduced. The new height can now fit more layers of trade units per one pallet with the increase in saturation from 80% to 100% with no variance as seen on the graph below.
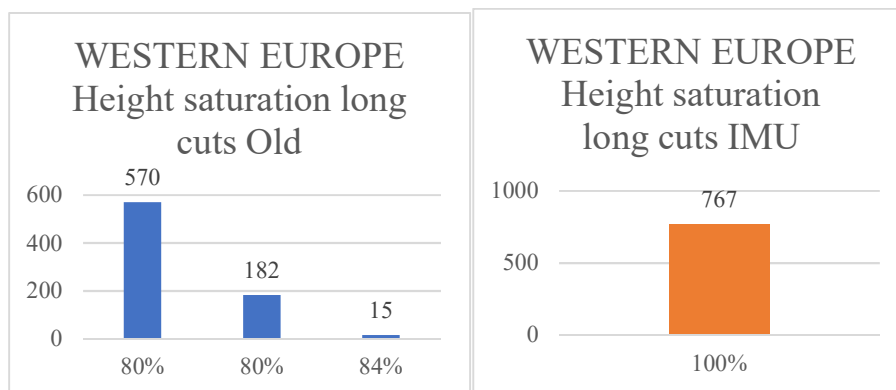
Figure 36. Long Cuts Height Saturation Western Europe

The width increases in place of the height due to the change in orientation. The saturation, however, increases from 90% to 100% with only 2 variances. From these data, all long cuts in Western Europe would have the same dimensions with IMU and all would maximize the pallet saturation in all dimensions. Another advantage for customers is that they can order any items available in Western Europe without needing to worry about their shelves as all the items have the same or at least similar dimensions. This added flexibility creates opportunities for Barilla to reach more customers which could not be reached before due to dimension issues.
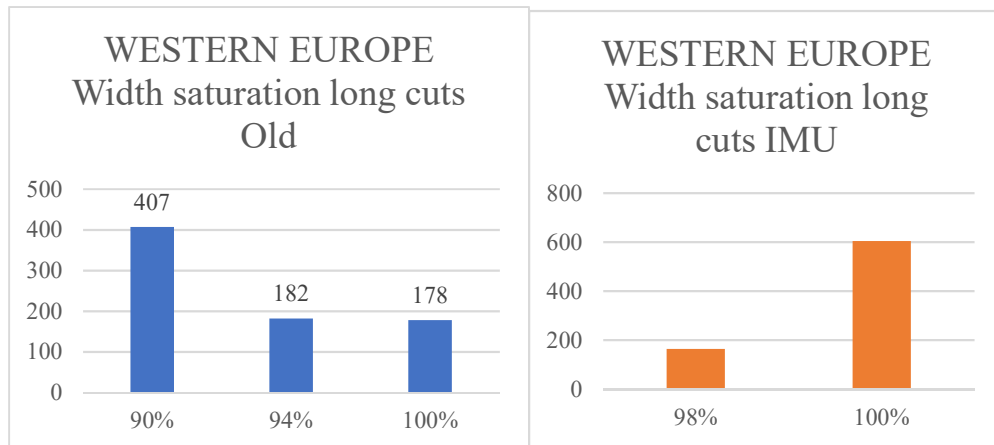
Figure 37. Long Cuts Width Saturation Western Europe

B. Short Cuts Pasta

The trade units of short cut pastas also receive better dimensions saturations in IMU versions. The short cuts are typically more modular than long cuts even before IMU. With the IMU versions, the length is reduced from 400 to 298 mm or from 600 mm to 590 mm. These dimensions are almost multiples but not exactly to give rooms for packaging thickness and tolerances, but they are both designed to have the final dimensions of 300 mm and 600 mm which are both the multiples of pallet length, 1200 mm.
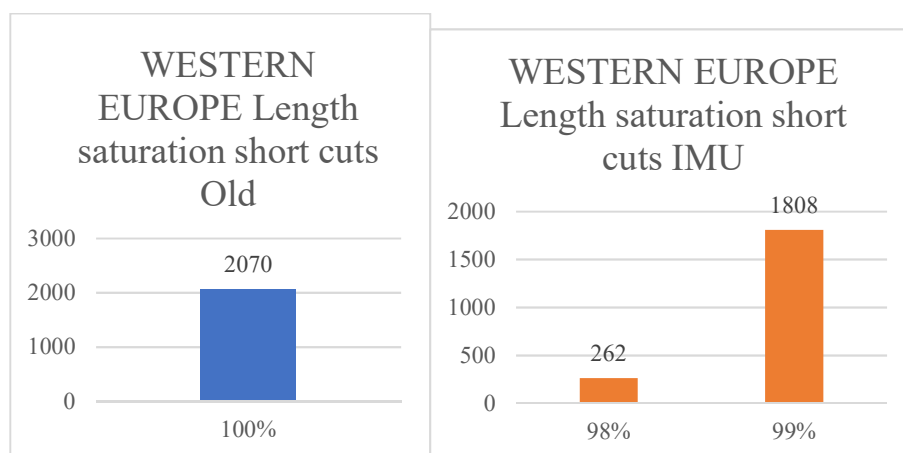
Figure 38. Short Cuts Length Saturation Western Europe

For the short cuts with 600 mm to 590 mm length reduction, the heights do not change by much and the number of layers remain. Meanwhile, for the trade units with 400 mm to 298 mm length reduction receive an increase in height. This increase sacrifices one layer of those with 6 layers to 5 layers per pallet for all short cut trade units in Western Europe. This increase in height better saturates the available height of the pallet and increase the saturation while compensates the decreased length. After the switch, all trade units of short repack items have the same number of layers.
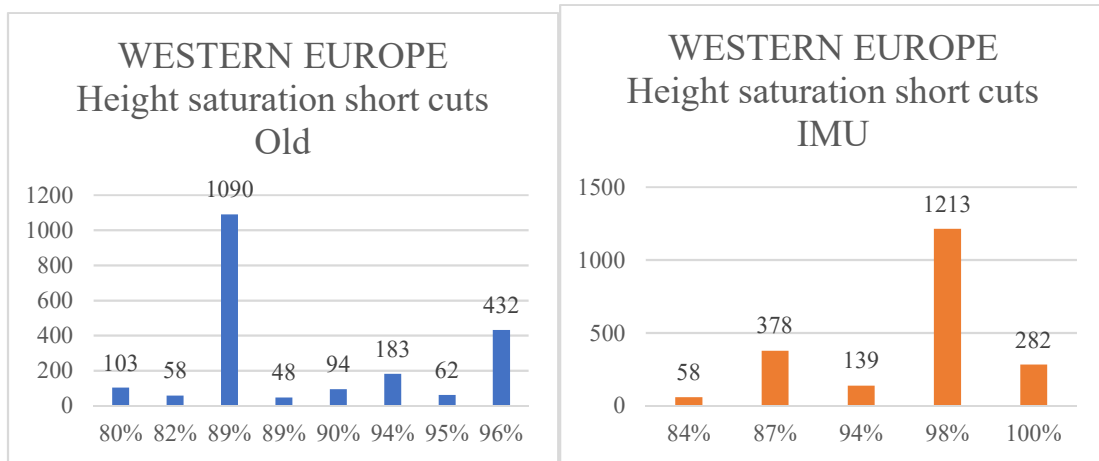
Figure 39. Short Cuts Height Saturation Western Europe
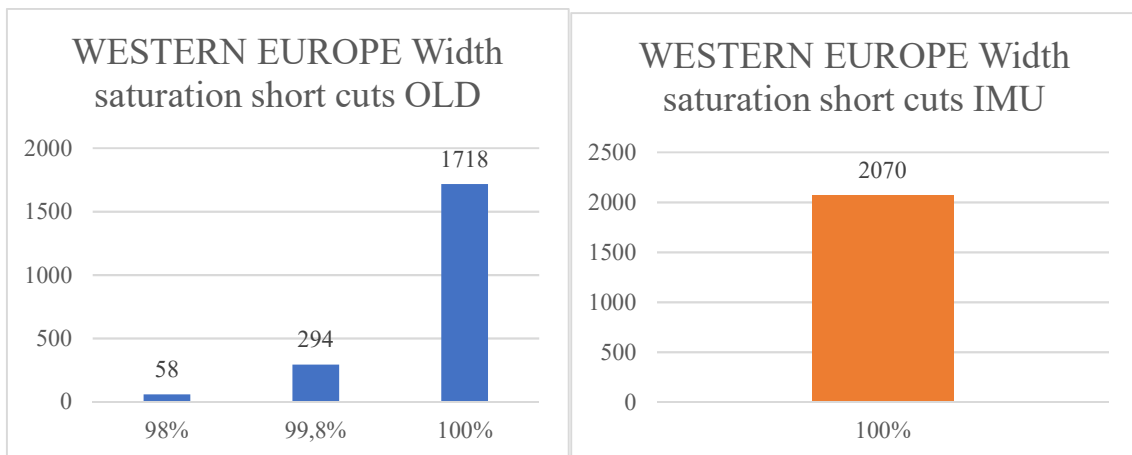
Figure 40. Short Cuts Width Saturation Western Europe

Finally, the width does not receive any alterations due to the fact that the width of the items was already a multiple of pallet width and the reduced length has been compensated by the height. The saturation of the width is already at 100% with a slight alteration of allowance.
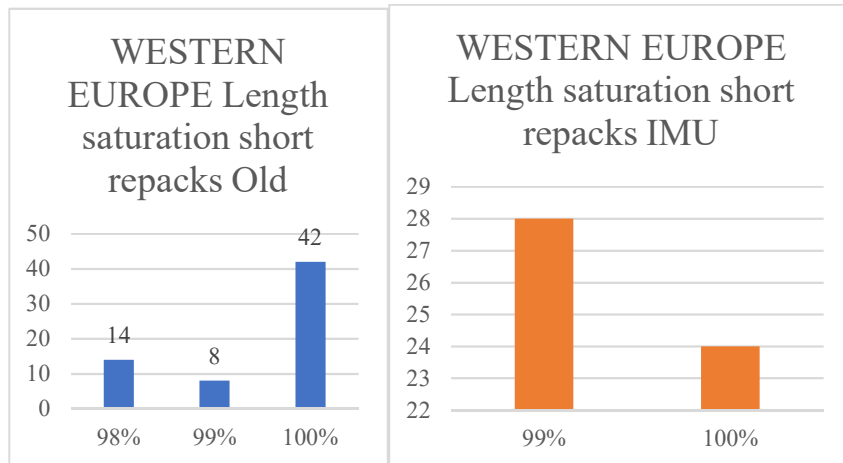
Figure 41. Short repacks Length Saturation Western Europe

In western Europe, there are Short repack items. This structural type includes 43 items of bundling or display units which specifically developed for certain market. Unlike the normal pasta cuts, the dimensions of repack items are more various from a bundle of 3 or 4 items to a half pallet display unit. Since the development of these repacked items is initially to satisfy certain customers, the initial dimensions really vary on different items. For the length of the trade units of these items, some items already have 400 mm length which fully saturates the pallet length, but some others have 780, 795 or 800 mm. These items with length close to 800 mm which is not a multiplication of 1200 mm are items with orientation B which face sideways. For these items, the length is reduced to 600 mm for while the items with orientation A with 400 mm keep their initial length.
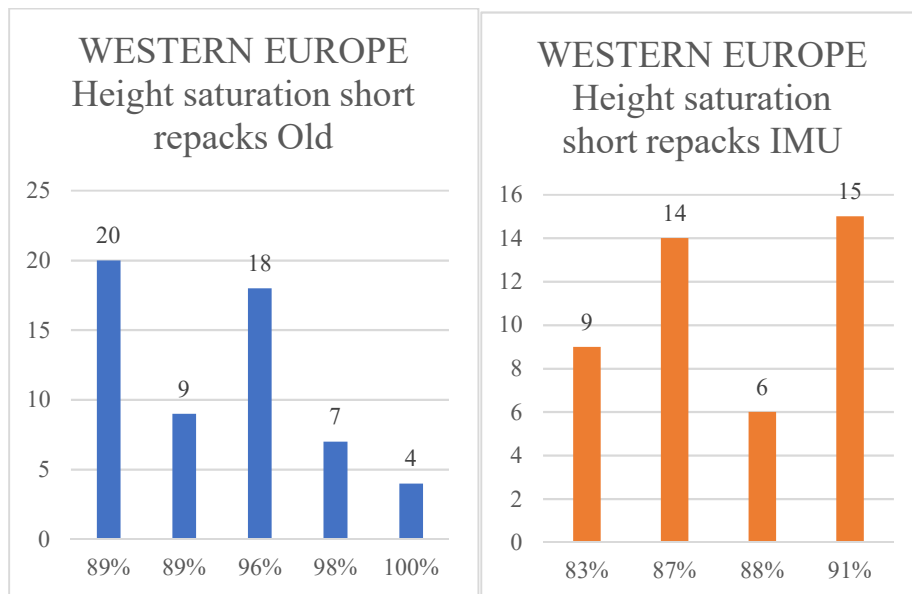
Figure 42. Short Repacks Height Saturation Western Europe

44

Unlike the length saturation, the height saturation analysis has an undecisive result. The switch to IMU generally results in higher saturation but in this case, it results in lower saturation; in fact, the maximum height saturation of IMU reaches only 91% while before it reaches 96%, 98% or even 100%. The conclusion that can be drawn is that the heights are used to compensate any changes in length ad width since unlike normal trade units, these repack items must have certain numbers of items in bundle inside the trade units. Therefore, reducing cases is not as easy since Barilla would lose one whole bundle.
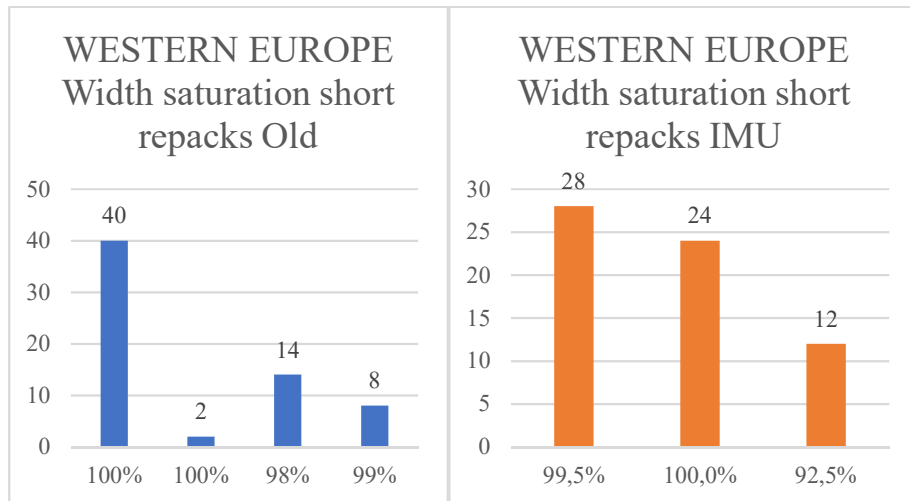
Figure 43. Short Repacks Width Saturation Western Europe

This change due to a request from a large, major customer in Netherlands and decreases the width saturation to 92.5%. The majority of the repack items receive width reduction only when a change orientation needs to be done as all IMU versions would need to face forward. These change in orientation causes a decrease in width from 600 mm to 400 mm.

III. Central Europe

A. Long cuts Pasta
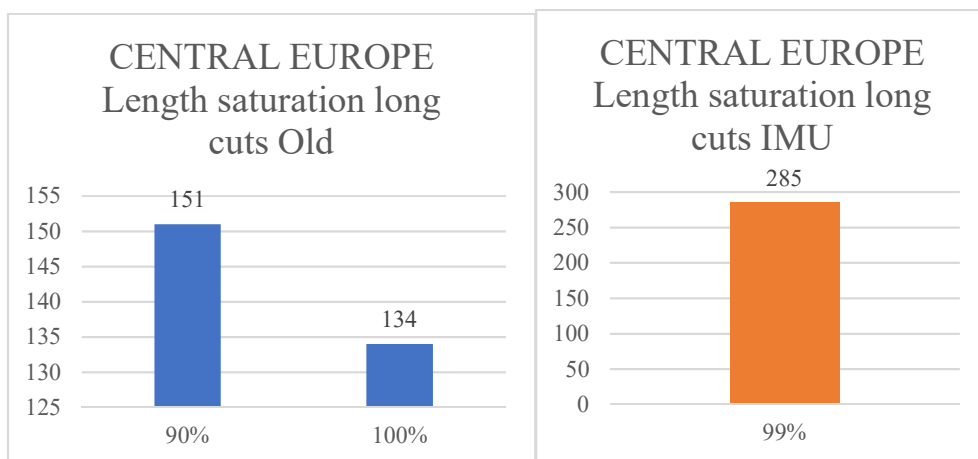
Figure 44. Long Cuts Length Saturation Central Europe

The trade units of long cut pasta in Central Europe typically have two saturations. The ones with 100% saturation typically already have a length close to 300 mm which are uniformed into 297 mm and results to 99% of length saturation while the ones with 90% saturation typically receives a reduction in length to 297 mm as well.
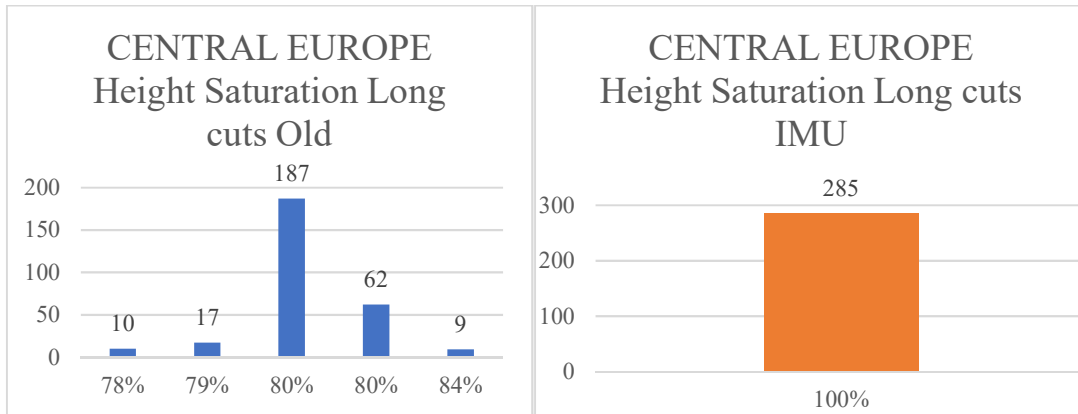
Figure 45. Long Cuts Height Saturation Central Europe

The unique thing about trade units of long cuts in Central Europe is that all items have one single length for all. Previously, there are various length dimensions for these items, ranging between 270 mm and 280 mm. These dimensions are reduced to 150 mm to compensate the increasing width of these trade units. 150 mm itself is a multiplication of 1050 mm, the available height of a European standard pallet and gives all long cuts items 7 layers each pallet.

For the width of the trade units in Central Europe, there are a high number of variances. These high variances result in various width saturations as well, ranging from 90% to 100%, but most of the items ended up with 97% of width saturations. The arrival of IMU gives advantages which uniforms the width of these long cuts into either 393 or 400 mm which is a multiplication of 800 mm, the width of standard European pallet. To achieve this width, most items receive addition in width which has been compensated by their decreasing height.
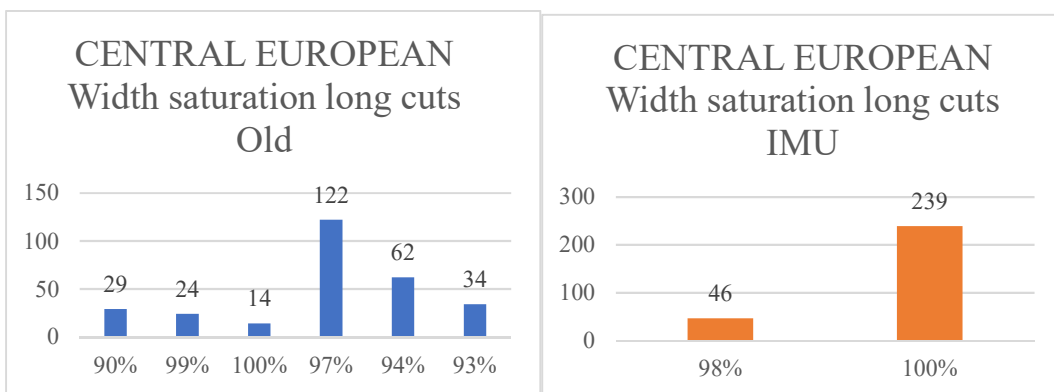
Figure 46. Long Cuts Width Saturation Central Europe
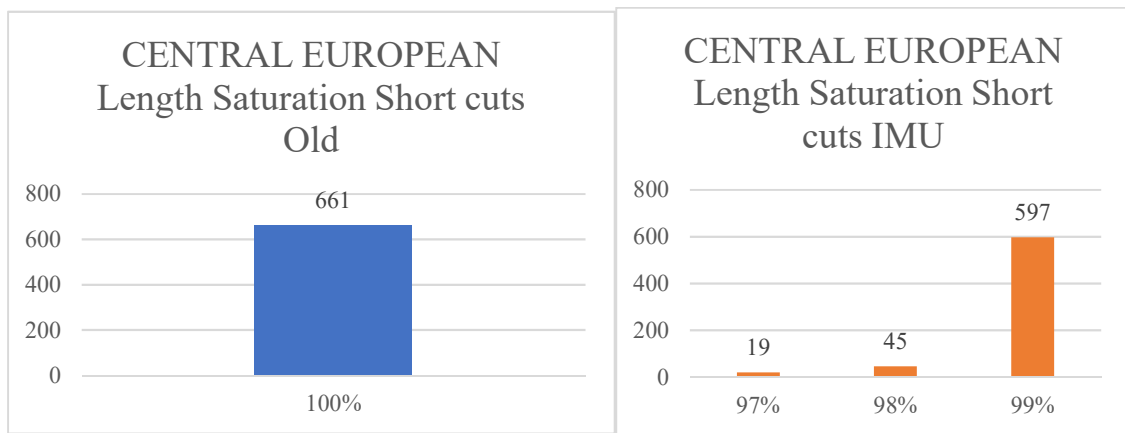
Figure 47. Short Cuts Length Saturation Central Europe

Just like in other regions, the short cuts typically already facing forward, thus no change of orientation needed. Old short cuts have two dimensions which are 400 mm and 600 mm which both saturate 100% the length of European standard pallet. However, to make it modular and similar to other regions, the length is reduced from 400 mm to 298 or 290 mm and 600 mm to 590 mm. This reduction would later be compensated by the height, exactly like what happened with IMU switch of Western Europe.
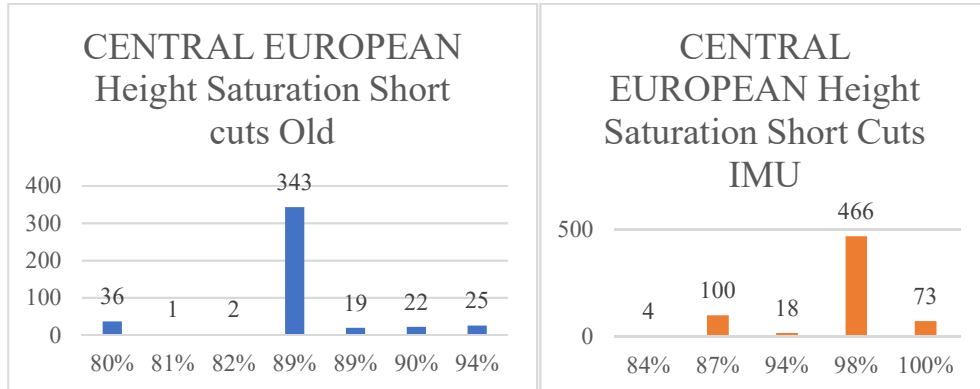
Figure 48. Short Cuts Height Saturation Central Europe

The decrease in length is compensated by the height. Previously, most of trade units of short cuts pasta in central Europe region have a length of 186 mm. After the switch to IMU, this height is increased to 205 mm which saturates better the height without losing any layers. For the widths, since all the short cuts already had the correct orientation, no change in both saturations and dimensions after the switch. The widths only receive 2 mm of reduction which is to give space to the packaging materials.

47
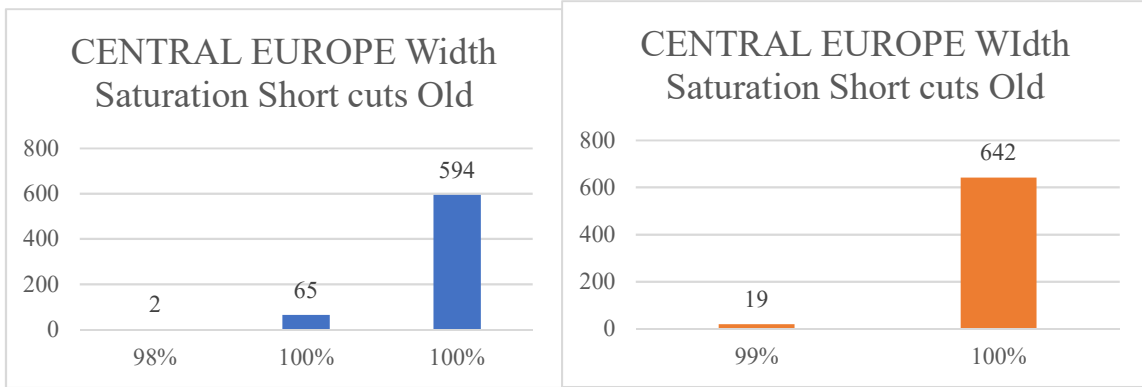
Figure 49. Short Cuts Width Saturation Central Europe

C. Short repack Pasta
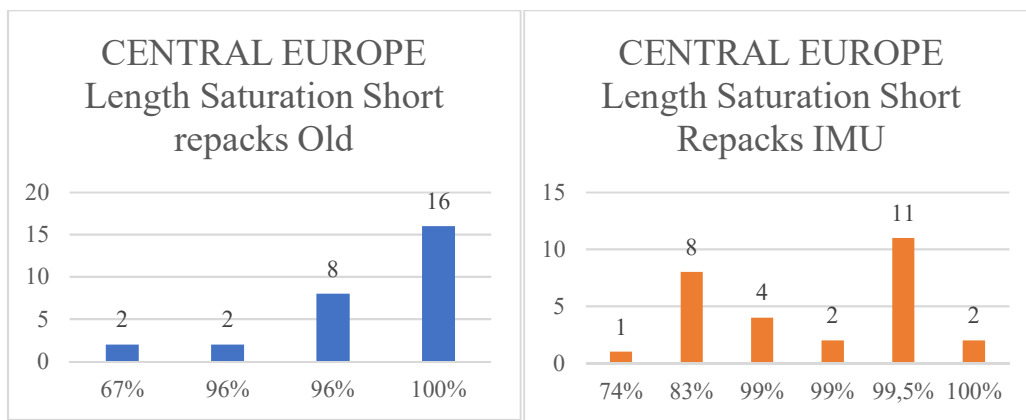
Figure 50. Short Repacks Length Saturation Central Europe

There are only 28 short-repacked items in the IMU switch plan of Central Europe, a very small quantity compared to other structural types. The old trade units of short repack items in Centrale Europe have 3 different dimensions: 300 mm, 400 mm and 600 mm. After the switch, the dimensions are narrowed into 2 dimensions, 400 mm and 600 mm. The variances in the dimension saturations are results of different tolerances given to the items which means that the lengths of the trade units are not exactly 600 mm but close.
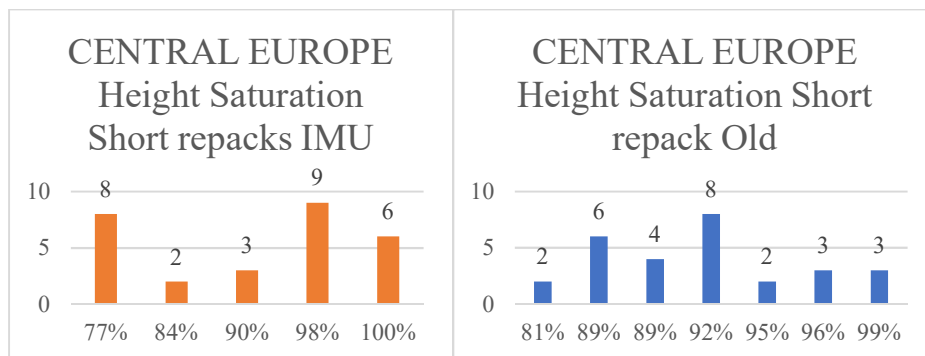
Figure 51. Short Repacks Height Saturation Central Europe

Meanwhile, the height is not as easy to observe. As seen on the graph of the heights, there are many different saturations for the height. Similar to what happen on the short repacks of repack items in Western Europe, the heights vary depend on the requirements of each repack items. The width of these repack items seem to be more vary after the switch and are used to compensate the height. If the IMU version had higher trade units, it would have narrower dimension. Overall, the saturations do not change much.
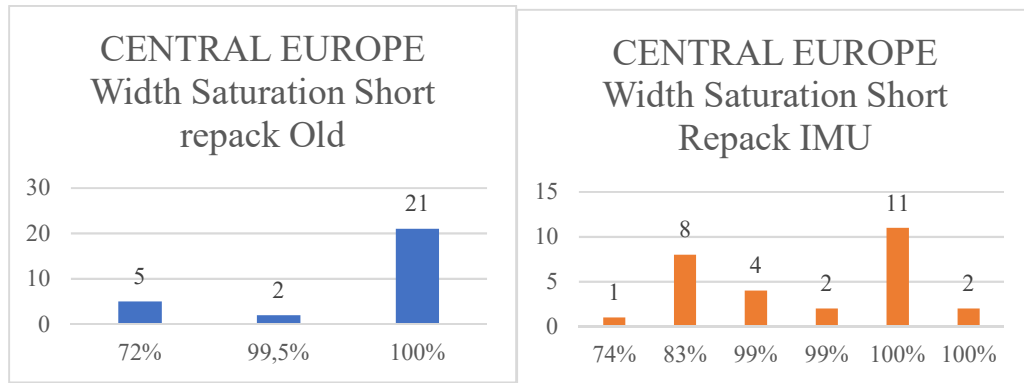
Figure 52. Short Repacks Width Saturation Central Europe

D. Long Repacks Pasta
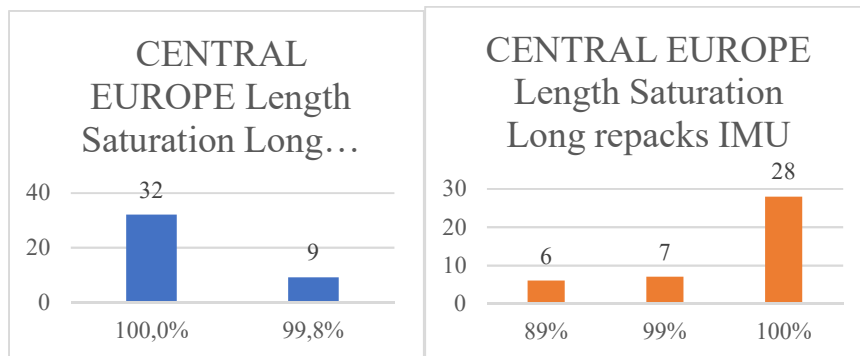
Figure 53. Long Repacks Length Saturation Central Europe

There are 41 long repacks item in Central Europe region and all are for Swiss market. Only 7 of these 41 items which would receive a change in length after IMU switch from 266 mm to 297 mm for items with orientation B and 300 mm to 297 mm for items with orientation A. Since 266mm is a multiplication of 800 mm, 300 mm is a multiplication of 1200 mm and 297 is also a multiplication of 1200 mm, there is no change in length saturation. However, it is important to notice that the IMU versions have 6 items with 89% of length saturation. These items with only 89% saturation are those which initially faced sideways. Therefore, their lengths, which are all 266 mm, were initially confronted with the width of European standard pallet, 800 mm, which results in 100% saturation. When switched to IMU which all should face forward, the 266 mm is now confronted against the length of the pallet which is 1200 mm and result in 89% saturation only.
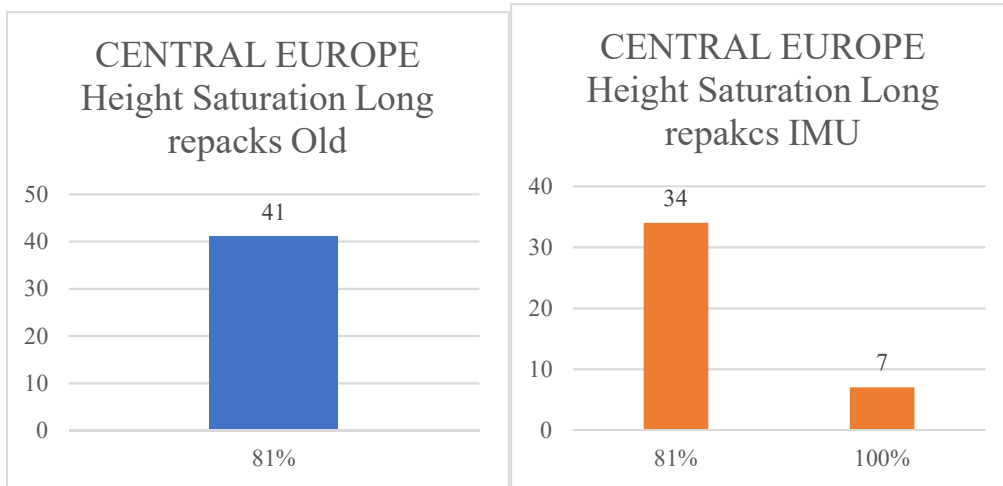
Figure 54. Long Repacks Height Saturation Central Europe

Unlike normal long cuts, most of long repacked items in Central Europe do not change orientation from vertical to horizontal although they are still rotated to facing forward. This explains the 34 items with the same height saturation after the switch while the 7 same items with length change receive their height changed and reduced from 285 mm to 150 mm which is the multiplication of 1050 mm, the available pallet height of Standard European Pallet.
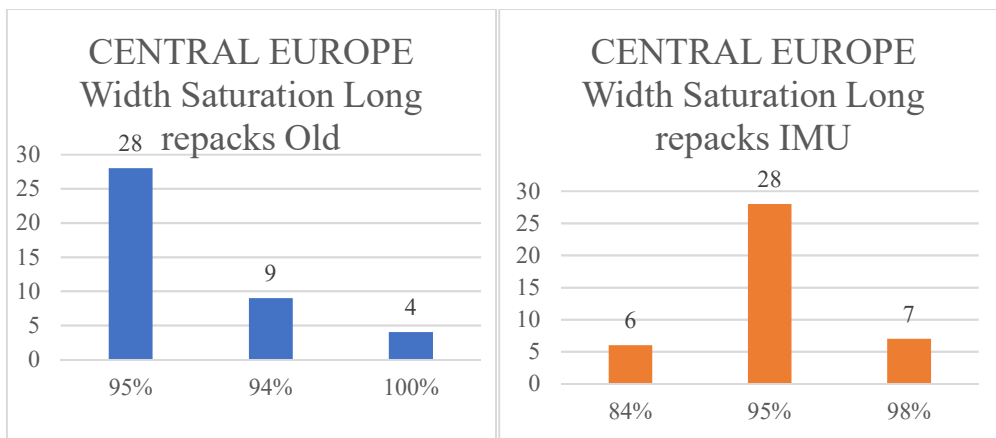
Figure 55. Long Repacks Width Saturation Central Europe

The width saturation is also affected by the fact that only 7 receive a change in dimension after the switch, just like the length and height saturation. While 28 of the items keep their 285 mm height with 95% saturation, the other 11 receive changes. Out of these 11 items, 7 are the items which receive change in dimensions, from 94% to 98%, while other 6 are the items which change their orientation from A to B without any changes in dimensions, resulting in a decreasing saturation of 94% or 100% to just 84%.

E. Mix repacks Pasta

The mix repacks pasta are display units which consist of multiple items put into a secondary packaging. There are 3 items only sold in Central Europe region and they all have faced forward before the change. After the switch, there would be no change in orientation nor in dimensions. Thus, they all keep their old dimensions and saturations, making them irrelevant to be talked about in this section.

IV. Great Eastern Europe

A. Long cuts Pasta
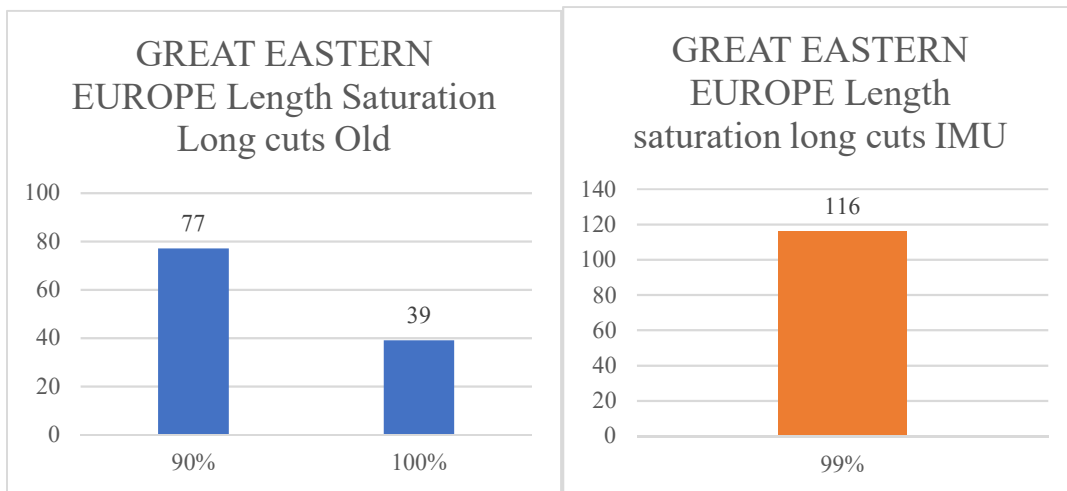
Figure 56. Long Cuts Length Saturation Great Eastern Europe

The trade units of long cuts in Great Eastern Europe region had two saturations: 90% and 100%. The trade units with 90% length saturation are those with orientation B and had 361 mm length, which when confronted with the width of a pallet, 800mm, becomes 90%. Meanwhile, those with 100% length saturations are trade units with orientation A or C with length close to 300 mm or 400 mm which both are multiplications of 1200 mm, the standard European pallet length. After the switch, all the items with all orientations are modularized to have one length, 297 mm which saturates 99% a pallet. All these items also only have one trade unit orientation, which is orientation A.
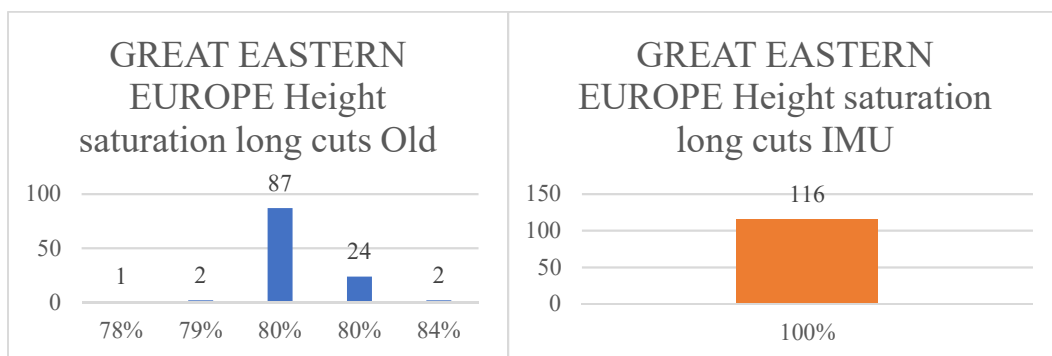
Figure 57. Long Cuts Height Saturation Great Eastern Europe

For the height, most of the trade units had 279 mm or 281 mm height with 80% of saturation and a little variance of trade units with 78%, 79% and 84%. After the switch, all these items receive just one height, 150 mm which saturates 100% Standard European pallet available height of 1050 mm with 7 layers. This modularization works well in Great Eastern Europe considering there was only one major dimension previously. This reduction of the height due to change of case orientation from vertical to horizontal is compensated to the width of the items which are all increased.
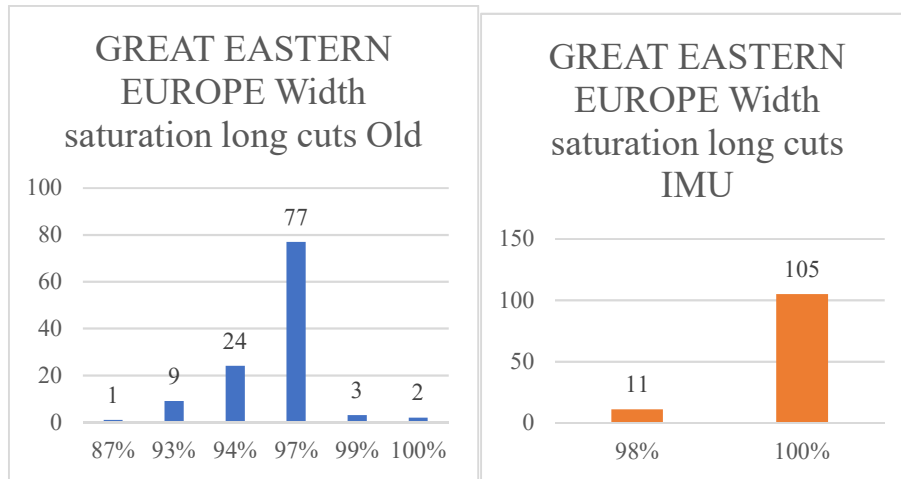
Figure 58. Long Cuts Width Saturation Great Eastern Europe

Most of the trade units had the width of 166 mm or 171 mm which saturate 94% or 97% a pallet width. After the change of case orientation from vertical to horizontal, the width compensates the reduced height and changes to either 397 mm or 400 mm which both are multiplications of 800 mm, the width of standard European pallet. Thus, the new IMU width saturation is either 98% or 100% which is higher and with less variance.

B. Short cuts Pasta
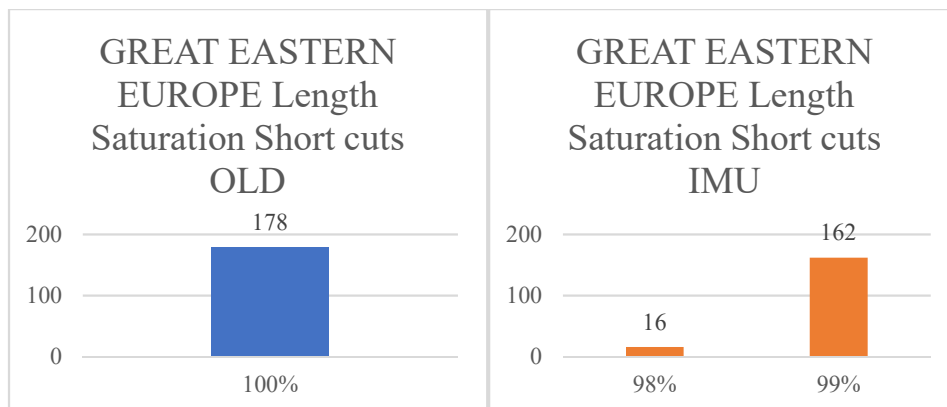
Figure 59. Short Cuts Length Saturation Great Eastern Europe

All trade units of short repacked items already have the correct trade unit orientation and the cases already have the right case orientation. Thus, all short cuts only receive one change in general:

reduced length which compensates the increasing height. All trade units of short cuts had either 400 mm or 600 length which saturates 100% a pallet length. After the switch, trade units with 400 mm are reduced to 298 mm which saturates 98% while those with 600 mm are reduced to 590 mm which saturates 98% a pallet length.

Since all short cuts had the same width and length, the height varied depends on the type of pasta cuts and the volume needed to reach a certain weight. However, most of the trade units had 186 mm which saturated 89% the available pallet height of 1050 mm. To compensate the decreased length, the heights are increased. Those with 186 mm are increased to 205 mm which eventually saturates 98% of the pallet. Trade units with other dimensions are also taller in IMU versions and they all have better height saturations.
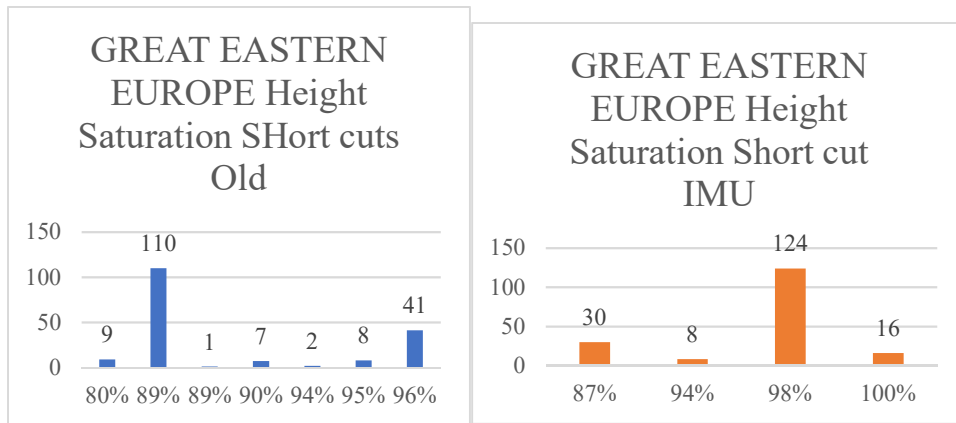
Figure 60. Short Cuts Height Saturation Great Eastern Europe

Before the switch, the trade units of short cuts had 2 widths, either 266 mm or 400 mm but mostly 400 mm. These two widths already fully saturate a pallet width and after IMU, all trade units only have one single dimensions, 398 mm which saturates also 99.5% of a pallet width. While the saturations do not change much, there are advantages from having a single dimension for all trade units in terms of logistics. It is easier to create a mix pallet and to sell various items to customers.
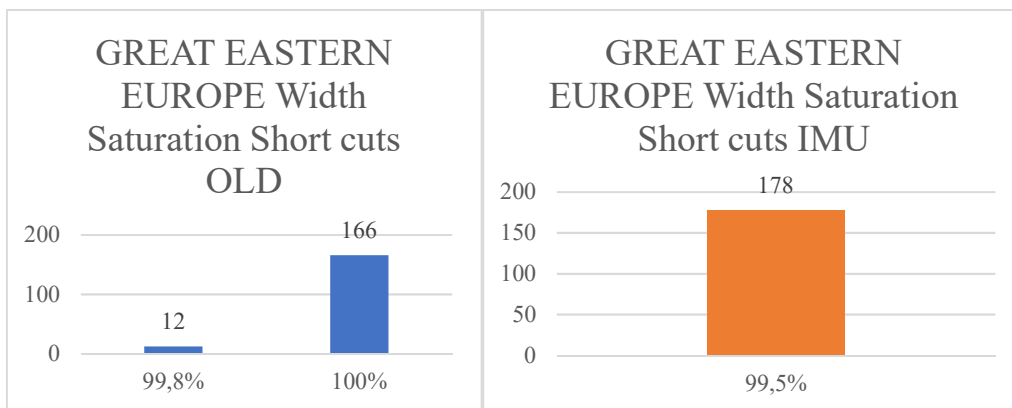
Figure 61. Short Cuts Width Saturation Great Eastern Europe

A. Long cuts Pasta
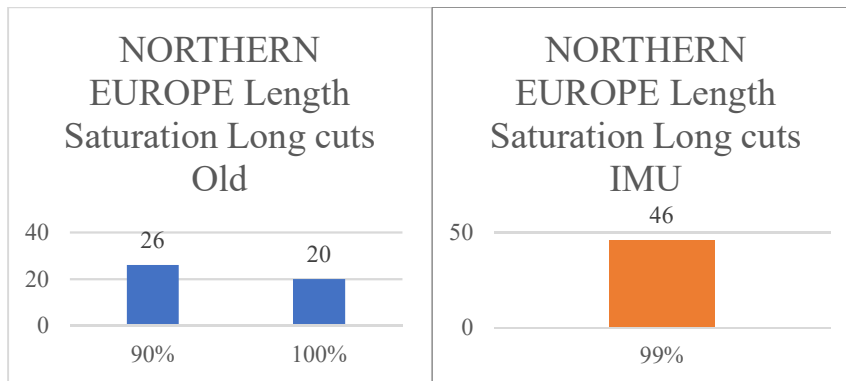
Figure 62. Long Cuts Length Saturation Northern Europe

Many trade units of long cuts in Northern Europe region have trade unit orientation C which means that they overly saturated a pallet. In the calculation, these items are considered to have 100% length saturation while those with 90% saturation are items with orientation B which have 361 mm length and when confronted with 800 mm, the width of a standard European pallet, the saturation is 90%. After the IMU switch, all trade units of long cuts would be rotated to orientation A with only have one length, 297 mm which saturates 99% a standard European pallet length.
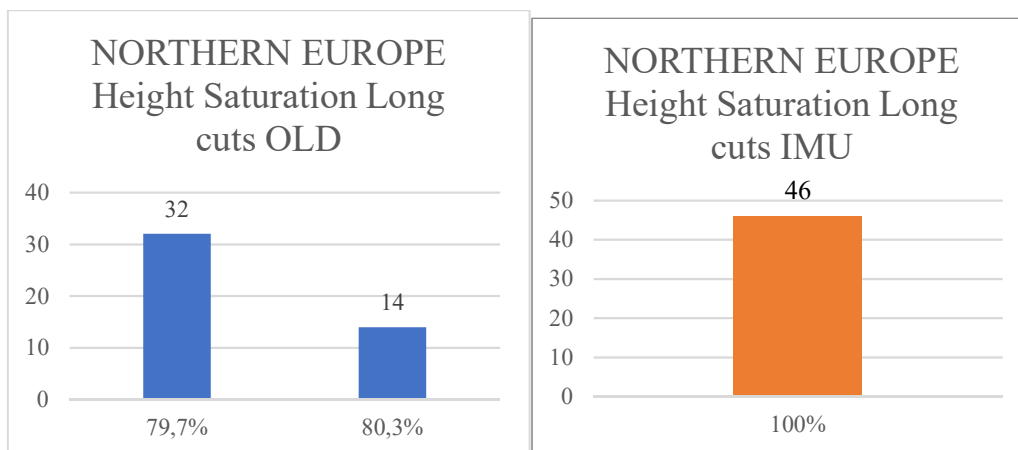
Figure 63. Long Cuts Height Saturation Northern Europe

Same with other long cuts in other regions, the long cuts receive a change in case orientation from vertical to horizontal. Following this change, the trade units of long cuts in Northern Europe receive a reduction in height to a single value:150 mm. The height of 150 mm results in 7 layers with 100% saturation, which means better dimension and less variance. This reduction of height is compensated by the increasing width as most items have B trade unit orientation.

Following the IMU switch, all trade units of long cuts would only have 2 widths: 393 mm or 400 mm. The trade units with 400 mm width end up with 100% saturation while those with 393 mm

end up with 98%. While this increase of width is due to the case change orientation from vertical and horizontal, the new widths seem to saturate better a pallet width of 800 mm and result in higher saturation. Beside saturation, the arrival of IMU versions create modularity where every trade units have the same length, width and height with a very slight variation due to different tolerances.
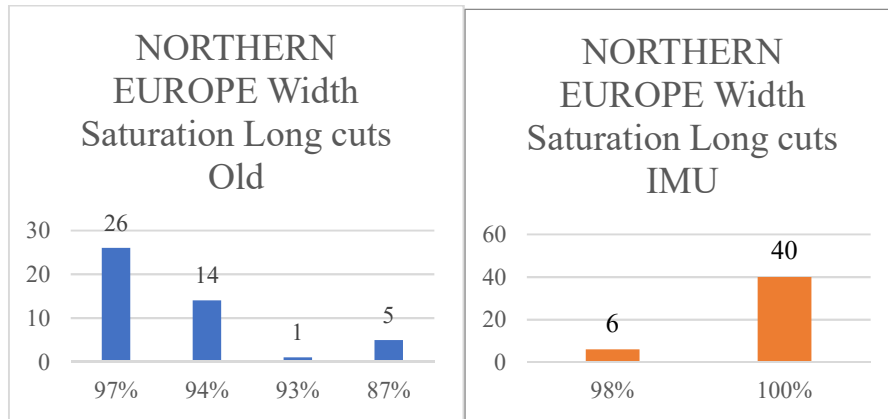
*Figure 64. Long Cuts Width Saturation Northern Europe*

B. Short cuts pasta
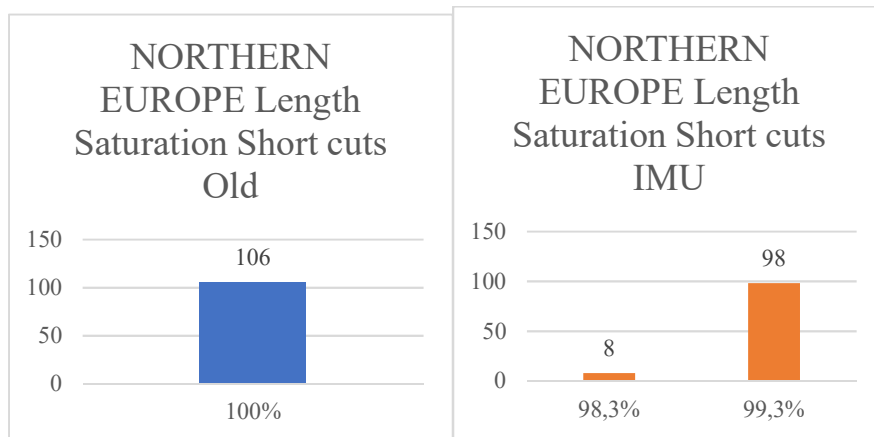
Figure 65. Short Cuts Length Saturation Northern Europe

The trade units of short cuts pasta already have the correct trade unit orientation A and had two lengths, 400 mm and 600 which both saturate 100% a pallet length. After the IMU switch, the lengths are reduced to compensate for the heights which haven't been optimized, from 400 mm to 298 mm and from 600 mm to 590 mm. The new length 298 mm results in 99.3% length saturation while 590 mm results in 98.3% length saturation.
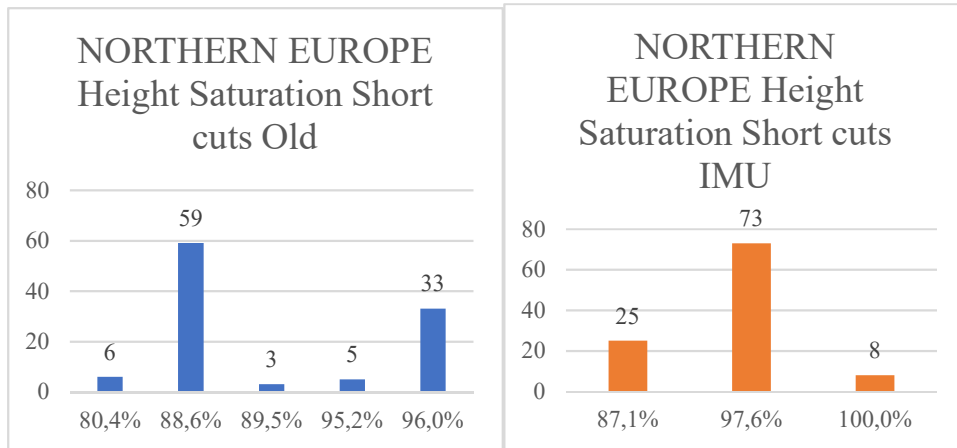
Figure 66. Short Cuts Height Saturation Northern Europe

Overall, the IMU versions are taller than the previous versions. After the switch, the saturations are higher, mostly 97.6% compared to mostly 88.6%. The heights vary to compensate the fact that all short repack items have the IMU versions with same width and length despite the types of pasta. Some pasta cuts may be less dense than some other, requiring more volume to achieve the same weight. However, most short cut trade units end with 205 mm and 97.6% width saturation.

Before the switch, the old versions had 400 mm width which 100% saturates a pallet width. After the switch, the widths become 398 mm to be more precise in the tolerances and end up with 99.5%. Overall, the widths do not receive any change and any additional variances. The short cuts in Northern Europe receive shorter length, higher height and the same width.
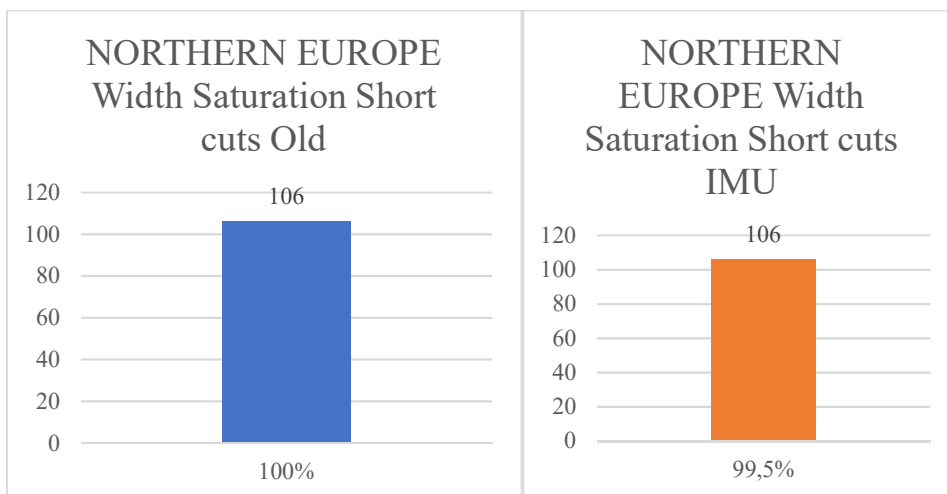
Figure 67. Short Cuts Width Saturation Northern Europe

VI. America

A. Long cuts Pasta
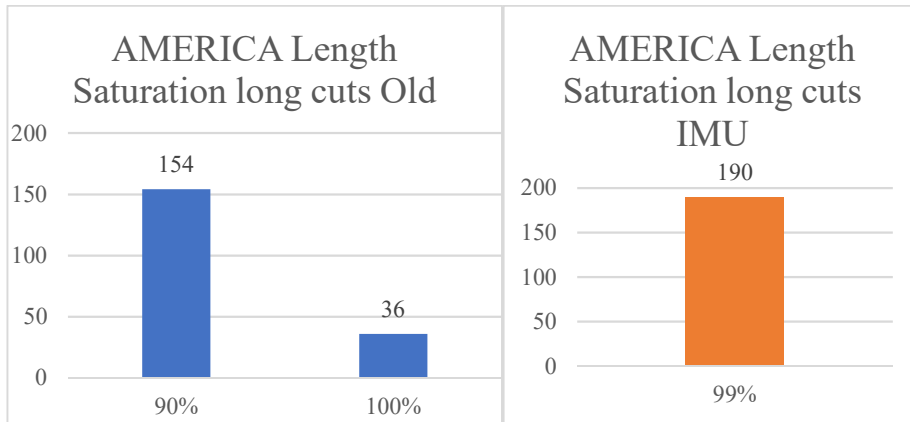
Figure 68. Long Cuts Length Saturation America

The trade units of long cuts in America region have either three different lengths but mostly 361 mm with 90% length saturation. However, most of these items have trade unit orientation B which means that trade units of long cuts in America would receive both trade unit orientation change to A and at the same time, case orientation from vertical to horizontal. After the switch, all trade units would have the same orientation A and the same length of 297 mm which saturates 99% a standard European pallet length.
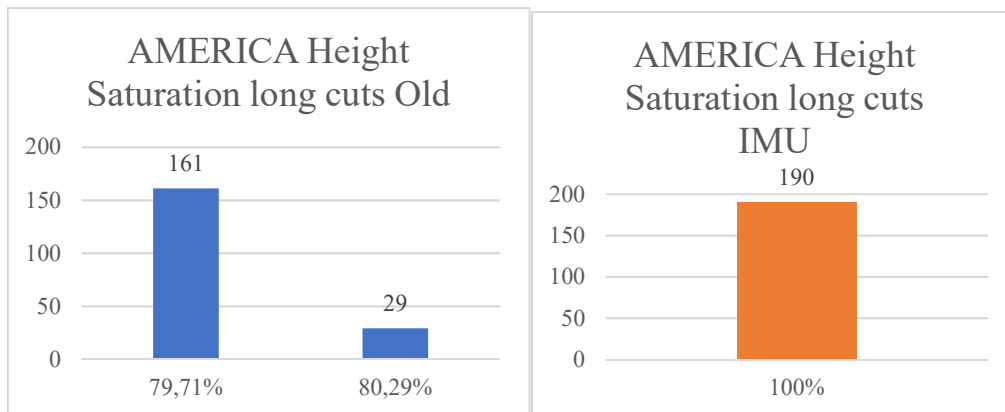
Figure 69. Long Cuts Height Saturation America

Before the switch, all trade units of long cuts already have similar heights: 279 mm and 281 mm which saturate 80.29% and 79,71%; respectively. After the case orientation change, the height is reduced into one value of 150 mm which results in 7 layers per pallet and 100% height saturation. The widths increase due to the same reason with height reduction into two values: 393 mm which

saturates 98% and 400 mm which saturates 100%. After the switch, all trade units of long cuts receive a high modularity.
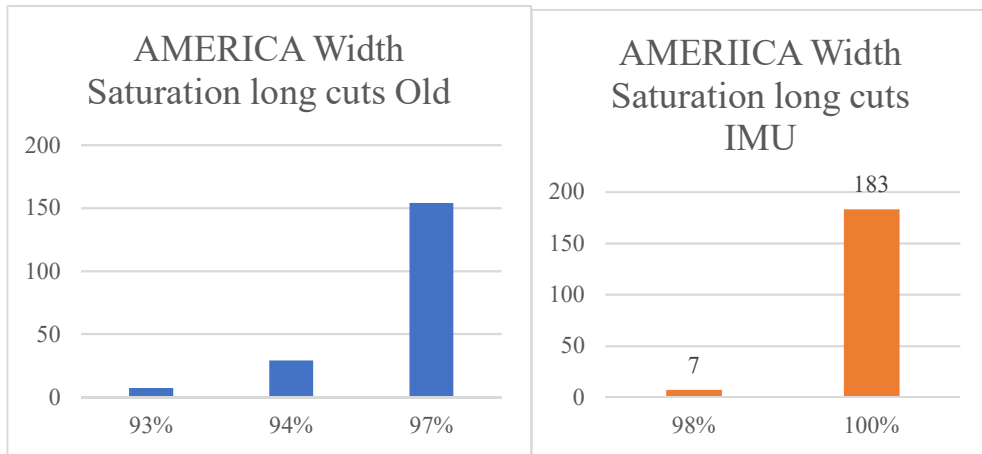
Figure 70. Long Cuts Width Saturation America

B. Short cuts Pasta
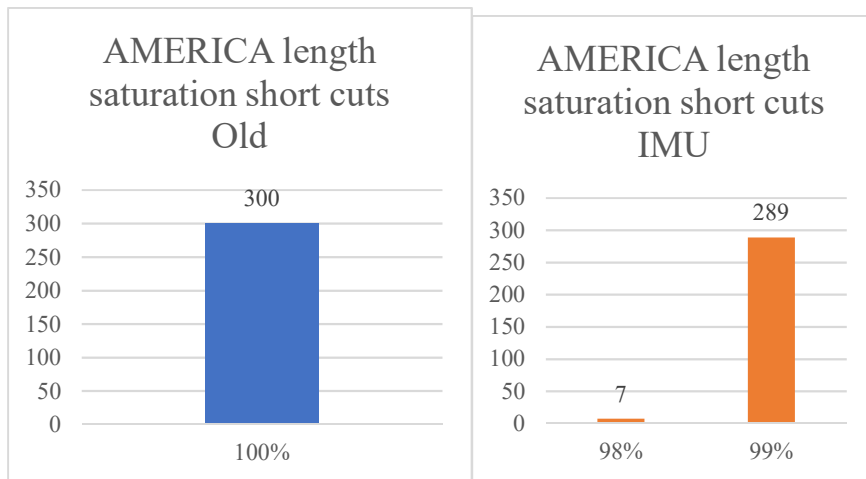
Figure 71. Short Cuts Length Saturation America

The trade units of short cuts pasta already have the correct trade unit orientation A and had two lengths, 400 mm and 600 which both saturate 100% a pallet length. After the IMU switch, the lengths are reduced to compensate for the heights which haven't been optimized, from 400 mm to 298 mm and from 600 mm to 590 mm. The new length 298 mm results in 99.3% length saturation while 590 mm results in 98.3% length saturation.
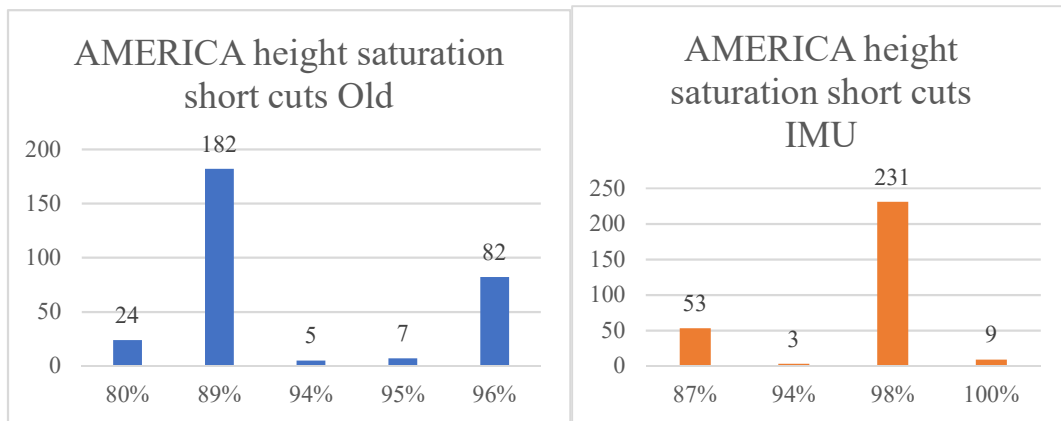
Figure 72. Short Cuts Height Saturation America

Overall, the IMU versions are taller than the previous versions. After the switch, the saturations are higher, mostly 97.6% compared to mostly 88.6%. The heights vary to compensate the fact that all short repack items have the same width and length despite the types of pasta. Some pasta cuts may be less dense than some other, requiring more volume to achieve the same weight. However, most short cut trade units end with 205 mm and 97.6% width saturation.

Before the switch, the old versions had 400 mm width which 100% saturates a pallet width. After the switch, the widths become 398 mm to be more precise in the tolerances and end up with 99.5%. Overall, the widths do not receive any change and any additional variances.
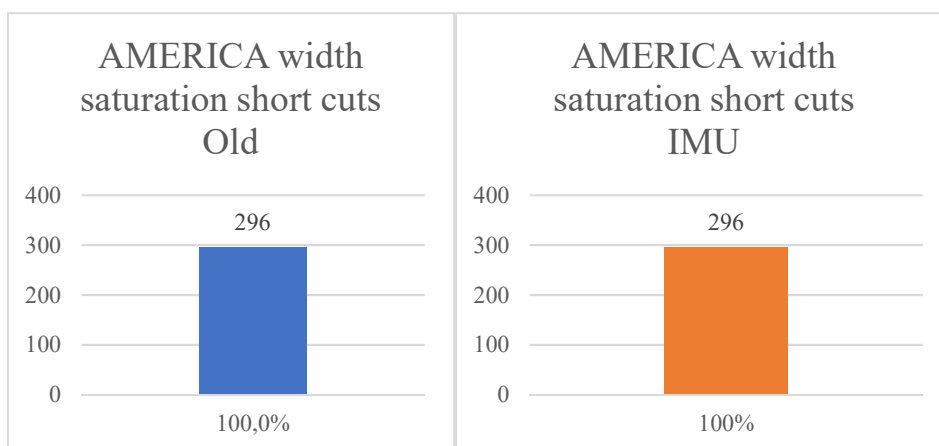
Figure 73. Short Cuts Width Saturation America

E.   IMU Pallet Changes Analysis

From the analysis on point B, it is clear that this switch to IMU would affect differently each region and each market due to difference in turnover involved while, point C and D explains the change to be measured: how the reduction in consumer units and the improving saturation affects the number of pallets sent. From the analysis in point C, it is obvious that with the same number of trade units per year, Barilla would send less cases to customers per trade unit which is the consequence of

having a better modularity and saturation as seen on analysis D. In this section, it is important to utilize these two important aspects: the magnitude and the change to finally understand how the result would be.

This chapter calculates the pallet difference per year after the IMU switch which may change due to the trade-off having less consumer units and the modularity. To perform an analysis, last year turnover is taken for each item in [tons/year] since the switch to IMU with new dimensions would not change the ordered quantity of the customers. Next, the new [pallets/year] with IMU could be estimated using the turnover [tons/year] divided by the new IMU [kg/pallet] which considers the number of consumer unit change and dimension change. A KPI, the pallet difference/year between IMU version and Old version, would be used to represent the estimated cost addition or saving since 88% of Barilla items are shipped on pallet and almost all are kept with pallet on the warehouse. The old pallet/year can be downloaded from Barilla's database also as an equivalent of [Tons/year] but on old item specifications. The results would be presented based on different structural type in percentage for the sake of confidentiality.

The formula is presented below:

$$\frac{TURNOVER \ 12 \ months \ [\frac{tons}{year}]}{IMU \ [\frac{kg}{TU}] * IMU \ [\frac{TU}{pallet}] * \frac{1 \ ton}{1000 \ kg}} = IMU \ [\frac{pallet}{year}]$$

$$\frac{\Delta pallet}{year} = TURNOVER \ 12 \ months \ [\frac{Pallet}{year}] - IMU \ [\frac{pallet}{year}]$$

Equation 4. Pallet DIfference Calculation Formula

I. AAA (Africa, Asia, Australasia)
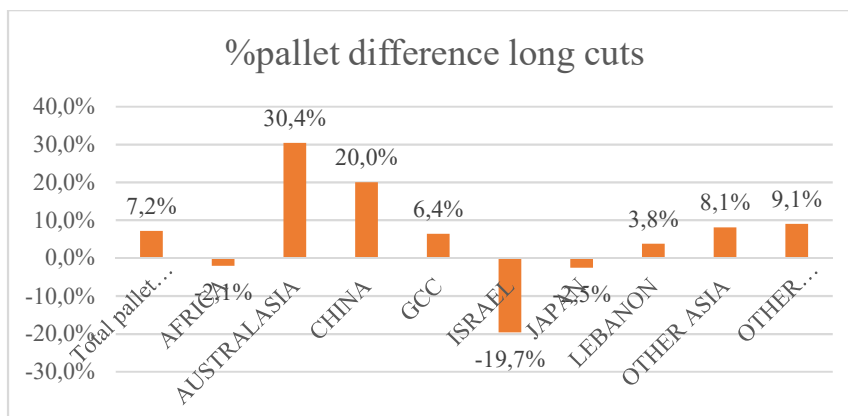
Figure 74. Long Cuts %Pallet Difference AAA

Figure 74 above shows the change of [pallet/year], in percentage, of long cut pastas in all markets of AAA region. Among all the markets, only Israel, Japan and Africa which receive a reduction in number of [pallet/year] with the arrival of IMU with -19.7%, -2.5% and -2.1%; respectively. Australasia leads the pallet addition with an astonishing increase of 30.4% with IMU versions. However, due to the difference in total pallet in each market, each change of the markets affects the total differently. In total, the long cut pastas in AAA region receive 7.2% increase to last year pallet after IMU switch.

The short cut pastas also receive an increase in pallet/year after the IMU switch. The difference is that all markets in AAA region have more pallets/year after IMU except Israel which receives a -1.1% decrease. The highest pallet increase would be in Australia, which receives 37.1% and the lowest increase would be in other Asia market with 7.7%. As an overall, short cut pastas in AAA would receive an increase of 19.2% from last year's pallet/year.
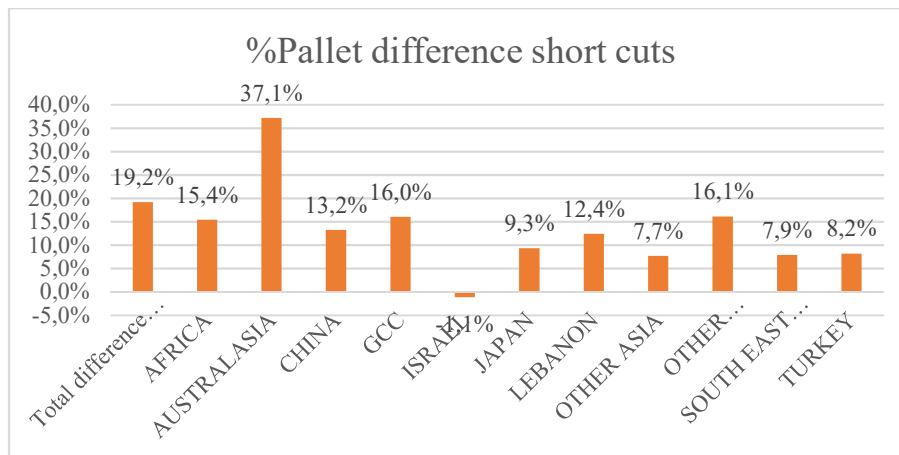
Figure 75. Short Cuts %Pallet Difference AAA

Since Australasia is the most impacted market compared with other regions, it is crucial to focus the analysis on Australasia. When combined, Australasia pallet increase covers 80% of the total 14.4% pallet increase in AAA region. To analysis Australia, the contribution of each item to the pallet increase is mapped as a moving sum and presented in the left graph of Figure 76. Out of 27 items which are included in the IMU switch plan in Australasia, both long and short cut pasta, the contribution to pallet increase is concentrated on the first 6 items. These 6 items, or 22% of the total SKU in switch plan Australia covers the 77% of the pallet change which creates a pareto. As for the right graph of Figure 76, a moving sum of weight turnover [tons/year] of these 6 items is also presented. The moving sum of weight turnover [tons/year] is mapped in the same order of items to see the correlation between pallet difference/year and turnovers [tons/year] since it is normal to assume that Barilla would have sent more pallets for items with higher turnovers. However, the result

shows otherwise. The 6 items which influence 77% of the pallet change only covers 61% of the annual turnover in AAA which shows that there might be other factors that influence the pallet difference.
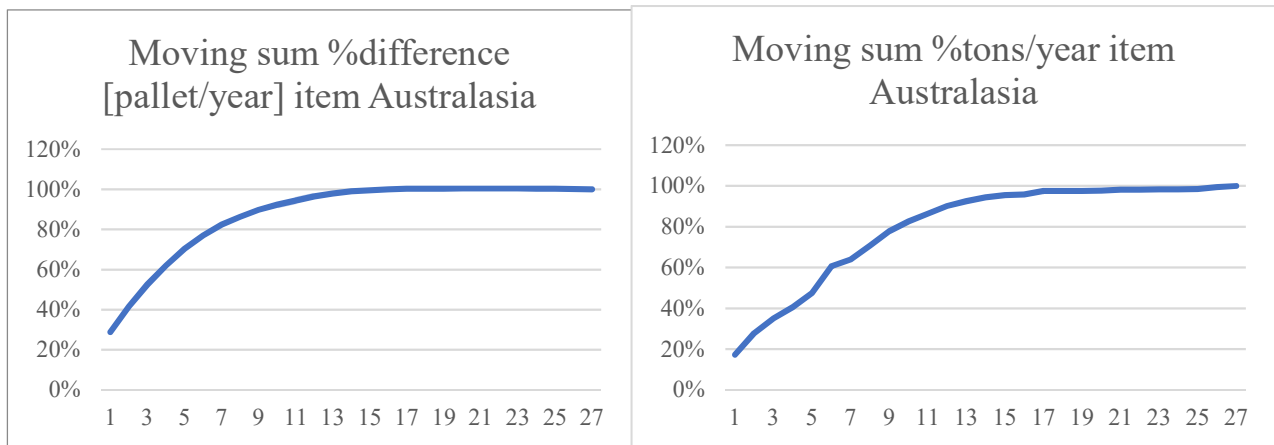
Figure 76. %Moving sum of [pallet/year] (left) and %Moving sum of [tons/year] (right) of items in Australasia

To understand the relation between turnover and the pallet used, the weight turnover [tons/year] and the pallet difference [pallet/year] of the 6 items are presented in two graphs below in Figure 77. Although no numbers would be presented due to confidentiality, it is obvious that item 6 had higher weight turnover [tons/year] than item 2 but item 2 had a higher [pallet difference/year].
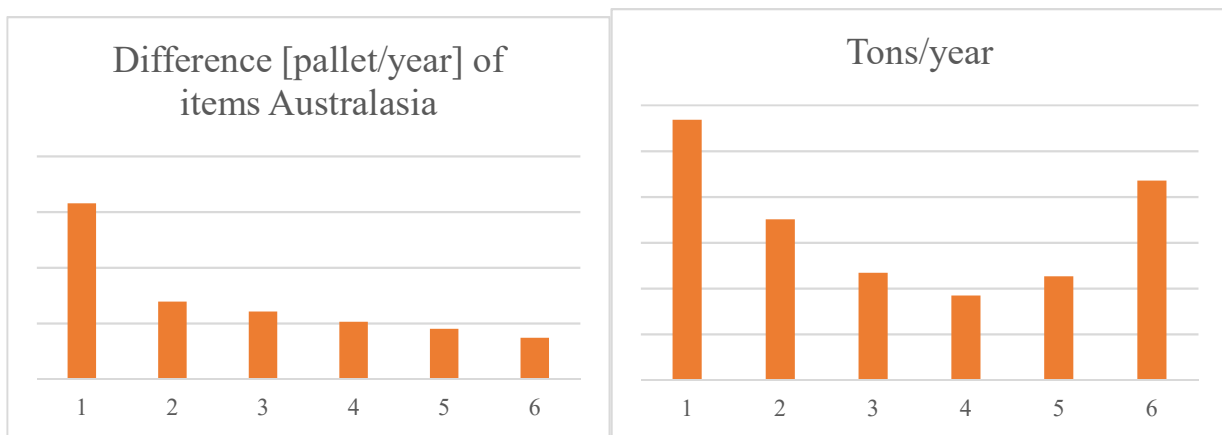
Figure 77. [pallet difference/year] (right) and [tons/year] of 6 items Australasia

This comparison shows that not all item with higher turnover would simply have more impact to the [pallet difference/year]. Apparently, it is important to also consider the [kg/pallet] of each item. Item 6 is a long cut pasta which turns out to have a higher specific density, causing them to have less pallet turnover [pallet/year] even with higher [tons/year] while item 2 is a short cut pasta which for the same weight turnover [tons/year], more pallets would be used. This insight gives an important point that when dimensions and or number of cases are changed, the short cut pasta or the item with less [kg/pallet] and highest weight turnover [tons/year] would be the most impacted. Thus, before

moving forward, short cuts pasta with high turnover should be a starting point and have their new [kg/pallet] checked.

II. Western Europe

Inside the Western European market, there are 6 markets: Portugal, Belgium, France, Netherlands, Spain and UK& Ireland. For these markets, there are three different structural types which are included in the switch plan: the long cuts, short cuts, and short repacked items. The long cuts receive a 1% reduction of pallet numbers after the change, short cuts with 2% additional pallets and finally the short repacks with -6% reduction. Overall, the region has 2% less pallets when IMU versions arrives which is mostly comes from France.
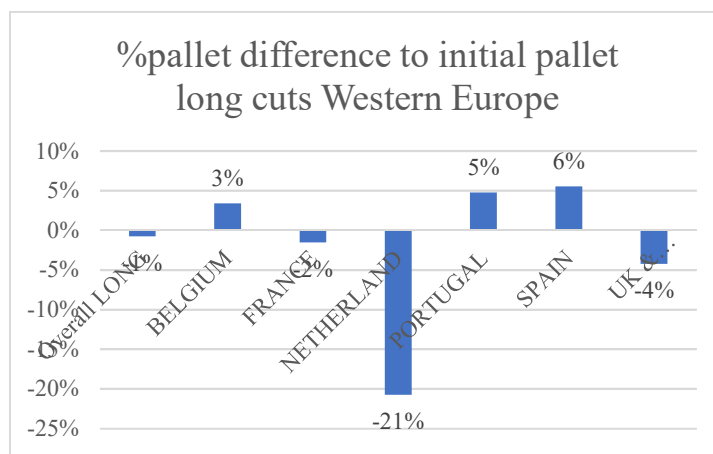
Figure 78. Long Cuts %Pallet Difference Western Europe

For the long cuts, Netherlands receive the most pallet reduction compared with its annual pallet turnover with 21%. France has 2% pallet less and UK & Ireland has 4% less when IMU arrives. The other markets do not have pallet reduction, but addition. Belgium receive 3% more pallets than before, Portugal with 5% and finally Spain with 6%.
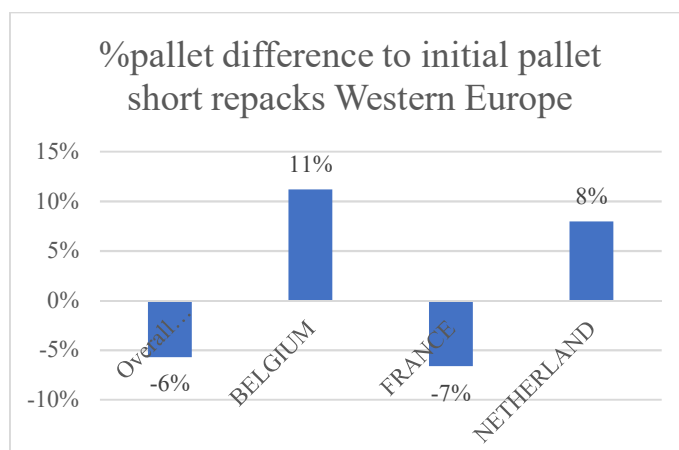
Figure 79. Short Repacks %Pallet Difference Western Europe

For the short repacks, there are only three markets which have them: France, Belgium and Netherlands. Belgium and Netherlands receive more pallets with IMU, 11% and 8%; respectively while France receives less pallets as much as 7% after IMU switch.
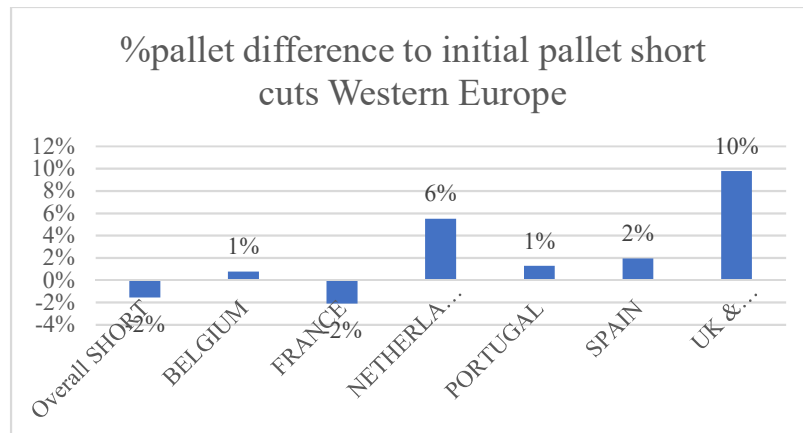
Figure 80. Short Cuts %Pallet Difference Western Europe

The last structural type is the short cuts. All markets under Western European region sell short cuts and all receive more pallets after the switch except for France. Belgium receive 1% pallet increase, Netherlands 6%, Portugal 1%, Spain 2% and finally UK & Ireland with 10%. France is the most dominant market in this region, and it receives -2% pallet reduction for short repacks. Overall, France covers 84% of the total pallet change in Western European region and would be analyzed further to understand how this large pallet reduction happens.
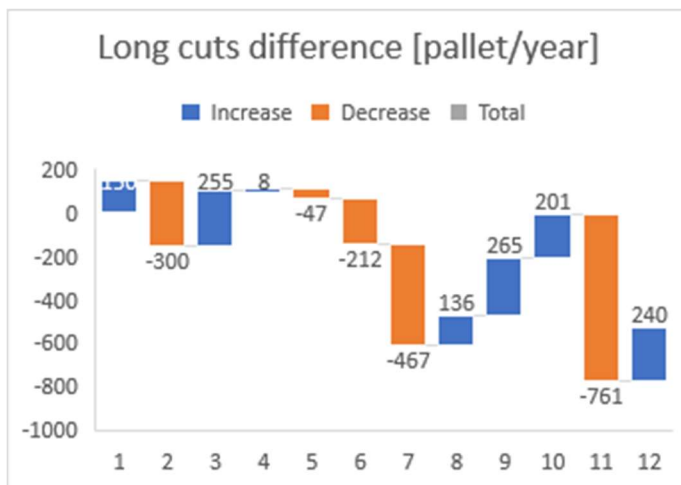
Figure 81. Long Cuts pallet difference for each item

The analysis would focus on the long cuts in France which is presented in Figure 81 which shows the pallet change of 12 long-cut items which are sold in France. The item names are not mentioned for confidentiality. By analyzing French market, there are two important outcomes to use when changing items' dimensions.

The first one is to focus on the items with highest pallet turnover. From this Figure 81, item 11, which had the highest pallet turnover last year receives the most pallet reduction with -761 less pallet/year. The second one is to focus on the added specific weight

Figure 82. Added Specific Weight of Item 2 and 7 of France

to capture the change on dimensions and weight at once. Item 2 on Figure 81 had more turnover than item 7 which can't be shown due to confidentiality.

However, as seen on Figure 81, it shows that item 7 has more pallet reduction than item 2. This is due to the fact that item 7 receives more additional specific weight than item 2 as seen on Figure 82. Specific weight is important since the cost rates of transportation and storage are mostly for one pallet place. Thus, the more weight put on one pallet place would mean more goods sold for Barilla without any additional cost.

By combining the insight from AAA and Western Europe explain that when changing dimensions of items are needed, it is important to focus on the items with less specific weight but with high pallet turnover and then to make sure that the new versions have a maximum added specific weight possible as these items would be the most impactful to the logistics performance.

III. Central Europe
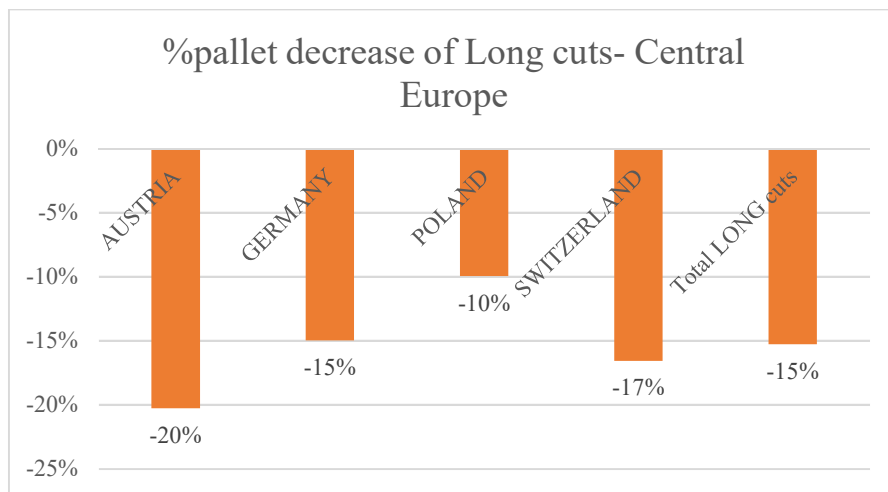
Figure 83. Long Cuts %Pallet Difference Central Europe

Central European market consist of 4 markets: Austria, Germany, Poland, Switzerland. For these markets, there are five structural types only: short cuts, long cuts, short repacks, long repacks, and mixed repacks or the display units. The focus of the analysis would be dedicated only for the long cuts and short cuts since if combined, they cover 97% of the change in Central Europe while others cover the remain. The long cut items receive a pallet number reduction of 15% overall while the short cuts have additional pallets of 0.4% after the arrival of IMU versions. Although not visible from Figure 83, Germany is the most dominant market as its -15% covers 65% of the overall pallet change while Austria, Switzerland and Poland cover the rest. For short cuts, Switzerland is more dominant than Germany, covering 37% of the 0.40% overall pallet change of short cuts in Central Europe.
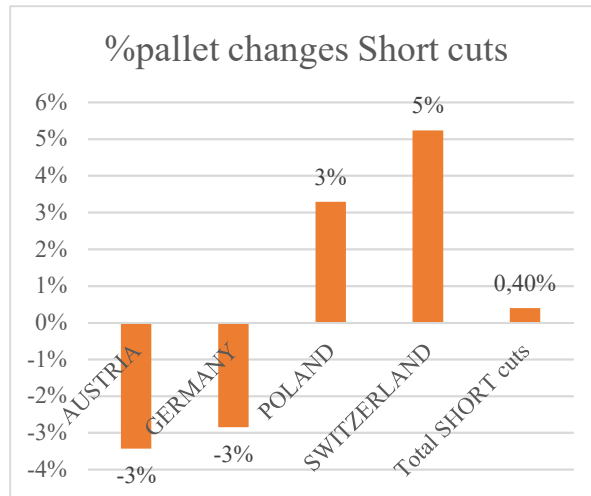
Figure 84. Short Cuts %pallet difference Central Europe

Germany covers a staggering 70% of pallet change in Central Europe. Due to this large number, a closer analysis is performed on the items that switched to IMU in Germany. Since most of the pallet reduction in Germany is on long cuts pasta, the analysis would focus on long cuts pasta. The analysis found that one item in particular covers 20% of the total long cuts pallet change in Germany and this 20% is a reduction which means that this particular item contributes to a large cost savings in Central European region. There are 16 long cut items involved in the calculation as pictured on Figure 85.

Figure 85. Moving sum of %pallet reduction of each item in Germany
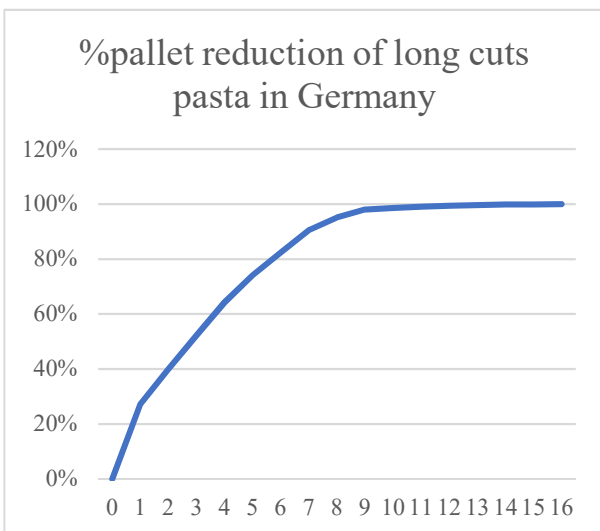
By looking on the specifications of item number 1 on Figure 85, some important insights can be studied. This particular item resulted a very high pallet reduction due to several factors. The first imporant factor is that this item does not receive any case reductions after change; there are still 24 cases after IMU switch although the trade units received a height cut from 276 mm to 150 mm to increase the heigh saturation since 150 is a multiplication of 1050.

The second factor is that due to this height reduction, there can be 3 additional layers/pallet from 4 layers to 7 layers/pallet whicn increase the number of trade units/ pallet from 48 to 56. Finally, due to additional trade units/pallet without case reduction, item 1 receives an additional weight/pallet from 576 kg/pallet to 672 kg/pallet which also means that the specific weight increases. This increase

together with the fact that it has such a high pallet turnover/year results in a high reduction in pallets/year. This item in particular should be used as a benchmark, if possible, when changing dimensions of other items.

IV. Great Eastern Europe

Figure 86. Long cuts %pallet difference Great Eastern Europe
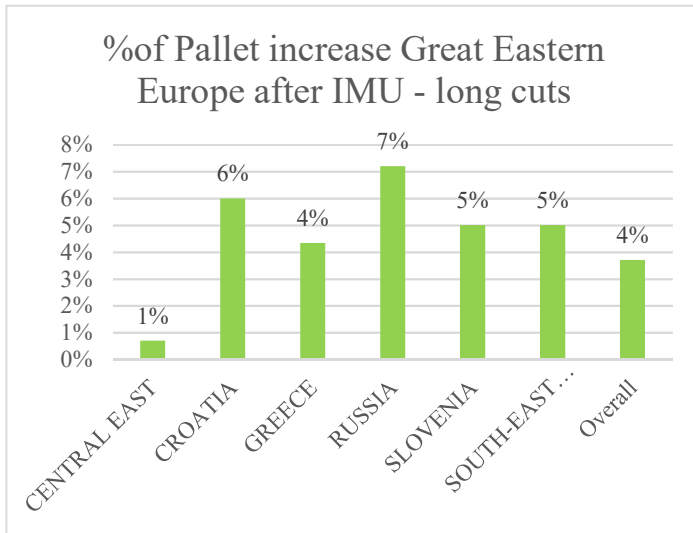
Great Eastern Europe market along with Northern European market and American market do not receive much change from IMU switch. There are two structural types of items which are in the switch plan of Great Eastern Europe: short cuts and long cuts pasta. There are 6 markets under Great Eastern Europe region: Central East, Croatia, Greece, Russia, Slovenia and South East Europe Other.

For the long cuts on Figure 93, all markets receive an increase in pallet numbers after the switch. Central east receives an increase of 1%, Croatia receives 6%, Greece receives 4%, Russia receives 7%, Slovenia receives 5% and finally South-East Europe others receives 5% of increase. Out of these 6 markets, Greece contributes to half of the total change. Overall, the region receives 4% of pallet increase after IMU switch.

For the short cuts on Figure 87, only Russia and Slovenia which receive less pallet after the IMU switch. Russia receives -1% less pallet while Slovenia receives -3.3% less pallet after IMU switch. Central East, Croatia, Greece and South East Europe Others all receive more pallets after the switch with 1.5%, 2.3%, 1.8% and 6.6%; respectively.
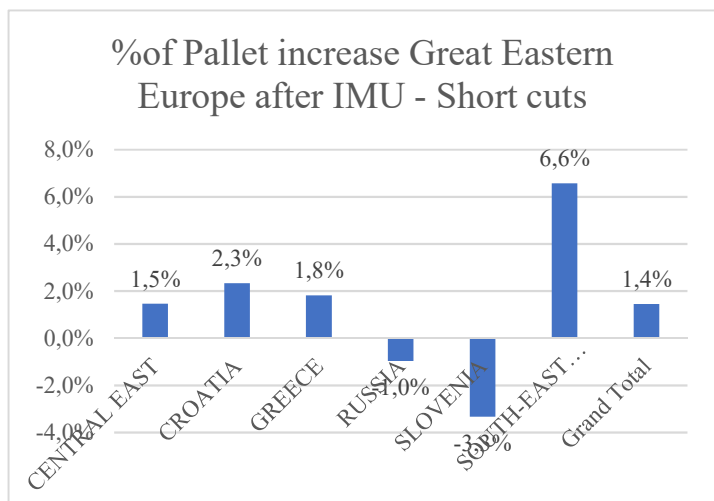
Figure 87. Short Cuts %pallet difference Great Eastern Europe

Combined with the long cuts, the region receives 2.2% more pallets after the switch. However, the change itself is not that big with the total pallet differences is only 15% of the pallet change in French market alone.

V. Northern Europe
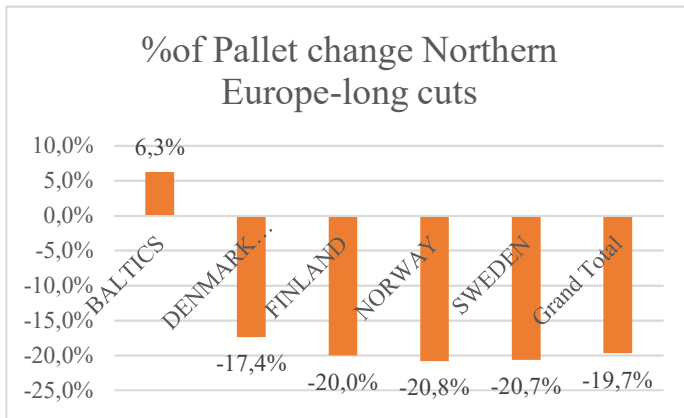
The Northern Europe region consists of 5 markets: Baltics, Denmark, Finland, Norway and Sweden market. There are only two structural types of items which are in the Northern Europe switch plan: Long cuts and short cuts. However, most of the pallet change comes from long cuts as the short cuts receive a very little change after the switch.

%of Pallet change Northern Europe-long cuts

BALTICS: 6,3%
DENMARK...: -17,4%
FINLAND: -20,0%
NORWAY: -20,8%
SWEDEN: -20,7%
Grand Total: -19,7%

Figure 88. Long Cuts %Pallet Difference Northern Europe

For the long cuts, Baltics market is the only market which receive additional pallets after the switch with 6.3% more pallet while the rest receive less pallet. Denmark market receives -17.4% less pallet after the switch, Finland with -20%, Norway with -20.8% and finally Sweden with -20.7%. Overall, the long cuts in Northern Europe have -19.7% pallet reduction with IMU switch. Sweden is the most important market in Northern Europe as it has the highest pallet turnover. Sweden also covers 74% of the pallet reduction of long cuts in Northern Europe thanks to 1 item. This item covers 39% of pallet turnovers in Sweden and contributes to 40% of the pallet reduction in Sweden.

%of Pallet change Northern Europe-short cuts

BALTICS: 1,7%
DENMARK /...: 1,4%
FINLAND: -0,4%
NORWAY: -3,9%
SWEDEN: 0,2%
Grand Total: -0,1%

Figure 89. Short Cuts %Pallet Difference Northern Europe
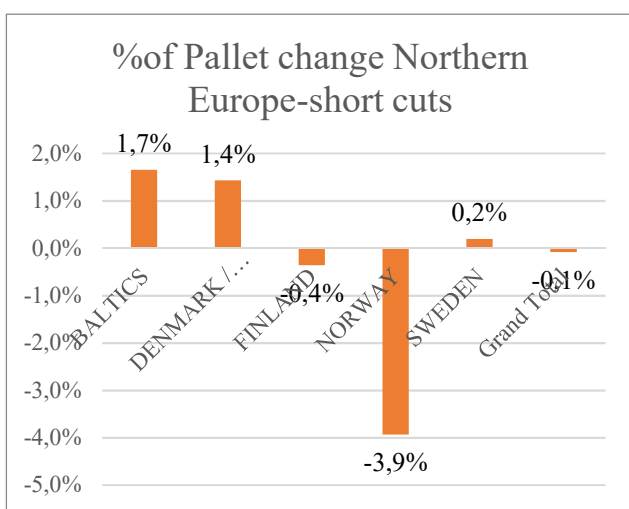
For the short cuts, there is not much change. Overall, the region receives -0.1% pallet change thanks to Norway. Norway and Finland receive -3.9% and -0.4% pallet reduction; respectively, while Sweden, Baltics and Denmark receive more pallet with 1.7%, 1.4% and 0.2%; respectively.
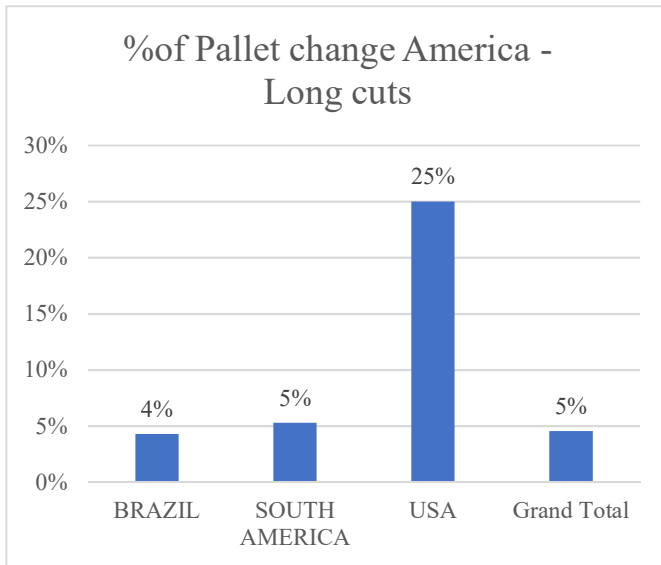
VI. America

Figure 90. Long Cuts %Pallet Difference America

American market probably receives the less pallet change compared with other markets. Most of the items with IMU versions are for South America, Brazil and Mexico market while there are only 5 items in the IMU switch plan of North America. Overall, the region receives 1.73% more pallets after the switch. Similar with North Europe region, long cuts receive more changes than short cuts although having less pallet turnover in a year.

For the long cuts, Brazil market has 4% pallet increase after IMU, South America has 5% and lastly, USA market has a staggering 25% pallet increase. This high pallet increase is caused by the fact that all long cuts in American region does not have any added Trade units per pallet but all IMU versions have less kg/pallet. Overall, the long cuts have 5% additional pallet compared with last year's pallet turnover.

For the short cuts, the overall change is very low, -0.9% less pallet than last year's turnover. Brazil market receive -3.1% less pallet as well as Mexico with -6% less pallet. Meanwhile, South American market receive 3.1% pallet increase and nothing for USA.

Figure 91. Short Cuts %Pallet Difference America

F.   Transportation Cost Evaluation

Transportation cost is the first cost valuation derived from the pallet difference analysis. Based on the previous deliveries, logistics department keeps track the total that Barilla paid for specific courses and the number of pallets that Barilla has sent and delivered. By diving the total cost of transportation of a period with the total pallets sent within the same period, a cost driver [€/pallet] can be obtained. Since Barilla delivered many different items using various modes of transportation, it is important to first filter the data. The selection of variables is as follows:

- Controlled Variables
  - Time   : 06.2018-05.2019
  - Type of Loading   : Palletized 1 and 2 level
- Independent Variables
  - Sales Organization   : all except Italy
  - Loading Modules
  - Country of origin
  - Destination country
- Dependent Variables
  - Transportation cost rate [€/pallet place]

From the variable selection above, there are 3 variables which help to give the right price: the country of origin, the destination country and the type of loading modules. There are also some exceptions for this method. Some countries that belong to the markets of Asia, Africa, Israel and Middle East receive their orders without pallet and in full containers. Thus, it is not correct to calculate based on the price of one pallet place. To perform this analysis, the total weight turnover between June 2018 and May 2019 is taken and is observed how the volume turnover would change if the items are switched to IMU versions given the same weight turnover. It is important to keep in mind that all containers previously sent were both weight and volume saturated. Thus, if there is an increase in volume for the same weight, there should be additional containers to be sent. Since the last year value is used to perform the analysis, the change in transportation cost is calculated based on volumetric weight cost rate [€/m3]. That is, if with IMU versions, the same weight turnover has lower volume turnover, there would be a saving while if for the same weight turnover, there is an increase in volume turnover, there would be an increase in transportation cost. The volumetric weight cost rate is obtained by applying filters

- Controlled Variables
  - Time   : 06.2018-05.2019
  - Type of Loading   : unpacked
- Independent Variables
  - Sales Organization   : all except Italy
  - Loading Modules
  - Country of origin
  - Destination country

- Dependent Variables
  - Transportation cost [€]
  - Quantity transported [M3]

By extracting this data using the filters above, a cost driver of [€/pallet] and [€/m3] can be harvested from the system and used to monetize the result for each pallet difference in section F. The results would be presented in % increase or decrease for the sake of confidentiality.

$$Palletized \rightarrow Potential\ savings \left[\frac{\Delta pallet}{year}\right] * cost\ rate \left[\frac{€}{pallet\ places}\right]$$

$$= \boldsymbol{Potential\ savings} \left[\frac{€}{\boldsymbol{year}}\right]$$

$$Non-Palletized \rightarrow Potential\ savings \left[\frac{\Delta M3}{year}\right] * cost\ rate \left[\frac{€}{M3}\right]$$

$$= \boldsymbol{Potential\ savings} \left[\frac{€}{\boldsymbol{year}}\right]$$

Equation 5. Potential Savings on Transportation

I.   Palletized items

During calculation process not all Sales Organization have their cost registered in the Headquarters' system due to different integration system. Those Sales Organization not integrated on SAP do not have their cost and other logistics KPIs recorded by Logistics Department in the Headquarters while those which are integrated do. If a Sales Organization is not recognized in the system, then it is removed from the calculation. For Italian market, the switch would take place as the third wave in 2020. Thus, it is not included in the calculation also.

To help readers interpret and understand the data, the pallet differences is calculated by subtracting the Old [pallet/year] with the new IMU [pallet/year] which are calculated using the same annual weight turnover but by switching the items which are in the IMU switch plan into IMU with IMU dimensions. Thus, a positive result explains that there would be less [pallets/year] with IMU versions while a negative result means that there would be more [pallets/year] with IMU versions. The same for the transport cost calculation, if the result is positive which means there would be less IMU [pallets/year], there would be a cost saving while if the result is negative which in this case means that there would be more IMU [pallets/year], there would be a cost increase.

A. Local Sales
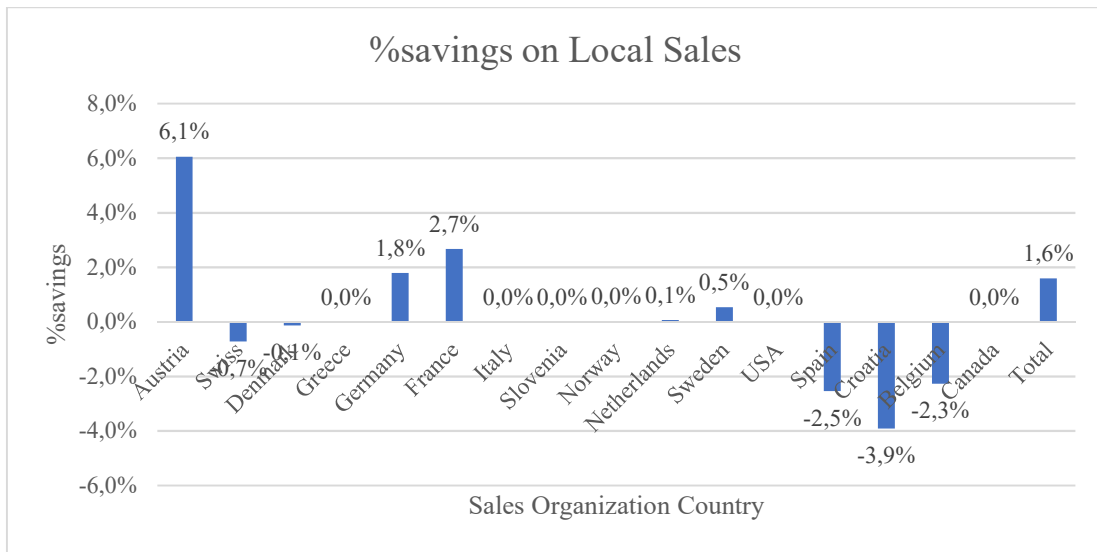
The graph above shows the percentage of cost change after the items with IMU versions have been switched. A positive percentage means that there would be cost savings while a negative percentage means the opposite. In a total, the transactions of local Sales Organizations would benefit from IMU with 1.6% of cost savings. Therefore, the total savings is not calculated by summing all the countries' individual percentage but by summing the total cost change and then divided by the total transportation cost for the same period.
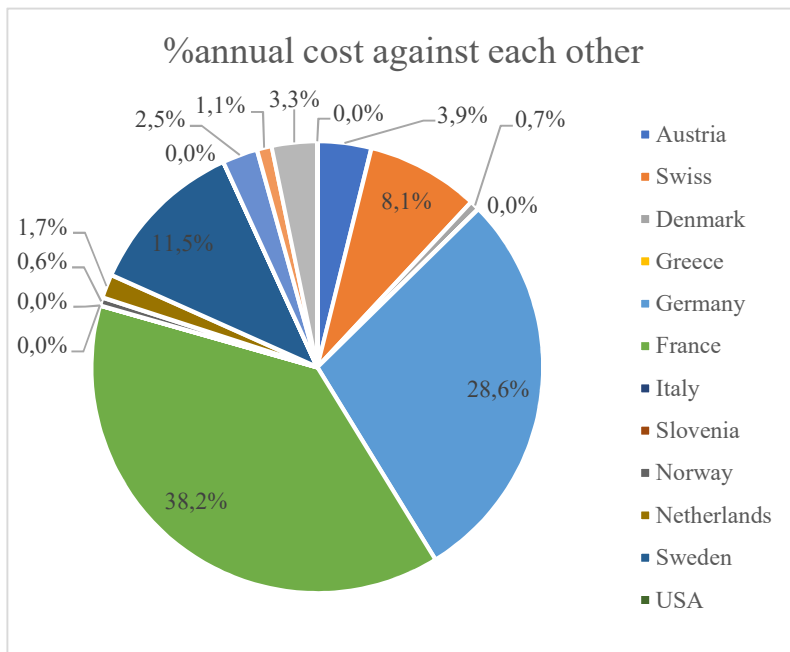
Since the real cost calculation cannot be published, the transportation costs of each country are compared to one another in percentages. When compared against one another as show on the graph on the left, it is obvious that more than half or almost 70% of the annual turnover of local sales organization comes from France and Germany.

Figure 93. %Savings on Transportation cost compared to one another

Due to this large annual turnover, any change would be less impactful compared with the others. In the first graph, the cost savings for Germany is only 1.8% while for France is 2.7%; way below Austria with 6.1%. However, the change in these two countries contributed the most in the total cost change. On the opposite, the countries with a cost increase are Spain, Croatia and Belgium with -2.5%, -3.9% and -2.3%; respectively with Belgium having the highest cost increase since it covers 3.2% of the total cost; highest among the other 2. Slovenia, Norway, USA and Canada do not have any changes recorded because no cost rate is found on the system due to lack of integration while Singapore only sends in containers which would be explained in the non-palletized calculation.

B. Intercompany Sales
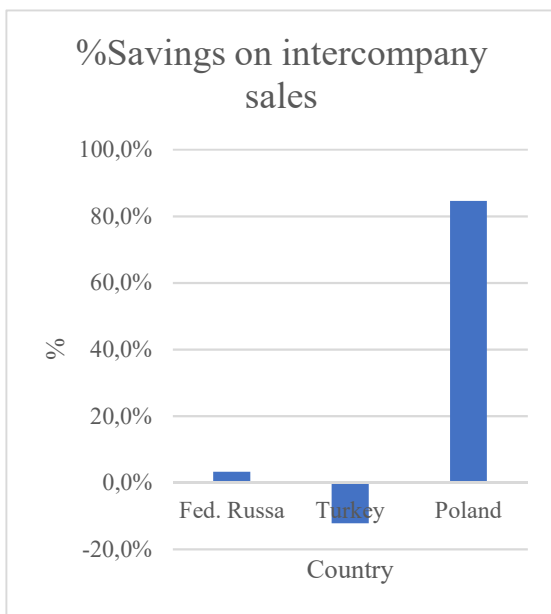
There are three countries covered by Italy Intercompany Sales Organization: Turkey, Russia and Poland. Overall, Italy intercompany sales receive 0.05% of cost savings by adopting IMU versions. Individually, Poland contributes the most to the savings by covering more than 80% of the total savings while Russia covers the other 3.2%. Turkish market would receive a cost increase by implementing IMU as much as -12.2% which mostly comes from one item.

Figure 94. %Savings on Intercompany Transportation

C. Export Sales
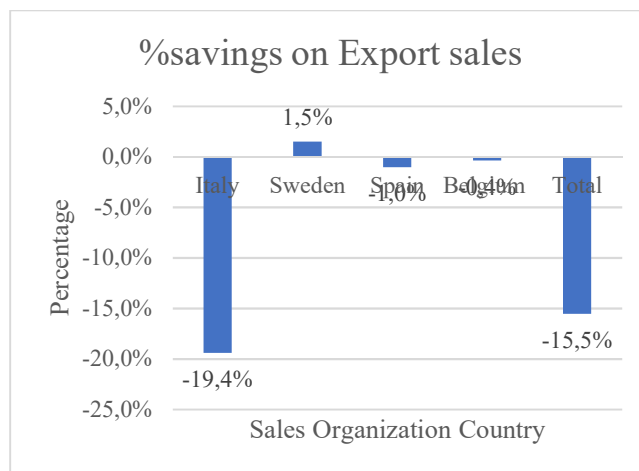
Figure 95. %Savings on Export Transportation

The graph above shows the percentage of cost change after goods with IMU versions have been switched. Overall, the export sales organization would receive a cost increase as much as 15.5% after IMU versions arrive. This cost increase is mostly contributed by the Italy export which receives 19.4% cost increase after IMU arrives. It is important to remember that the value of each percent is different for different countries because of different turnovers in the calculation. However, since the Italy export sales covers 80% of the total export sales in a year, it is safe to say that the cost increase in Italy export market mostly contributes to the overall cost increase.

Moving the focus to the markets inside Italy Export, there are 5 markets which would be affected by the arrival of IMU versions: Central East, Other Export, Portugal, Slovenia and UK & Ireland. Out of these 5 markets, Other Export seems to be most affected as it covers 45% of the 19.4% of cost change in Italy Export and it actually receives a cost saving from the arrival of IMU. However, the rest of the markets receive cost increase with Portugal having the worst cost increase which covers 39% of the 19.4%.
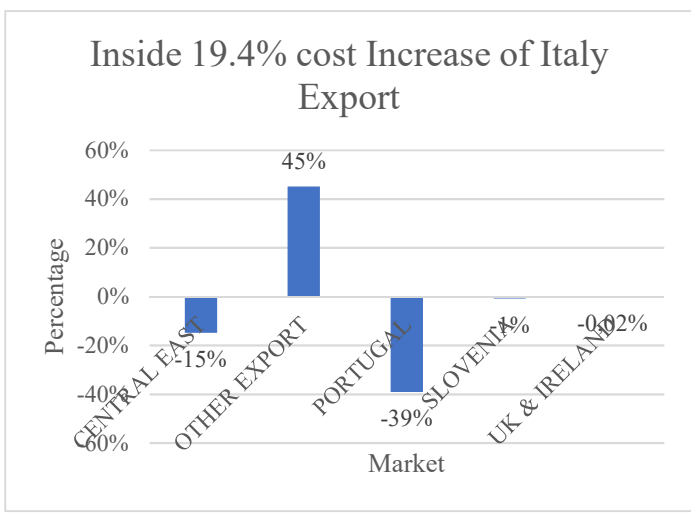
Figure 96. %savings on markets under Italy Export

D. Summary of Palletized Items
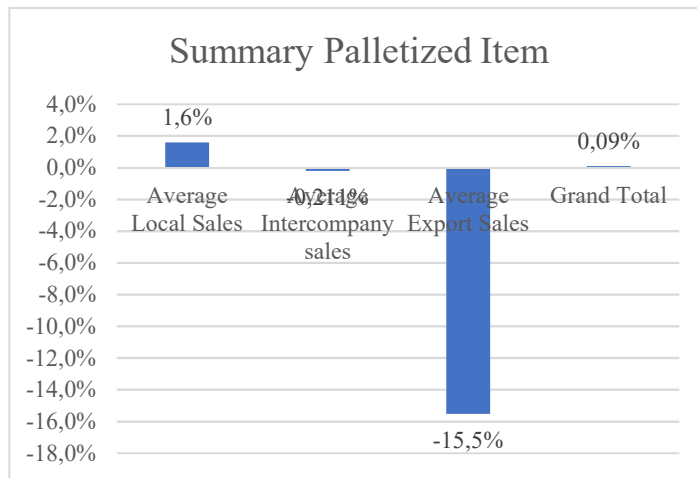
Figure 97. Summary on %savings of Transportation Cost for Palletized items

Figure 97 summarizes all the previous calculation. From 3 categories of Sales Organization, local sales and intercompany would receive cost savings when IMU versions arrive although very minor savings from intercompany. The local sales savings are mostly earned in French and German market while for intercompany sales, the saving is earned from Polish market. On the contrary, the Export Sales receive a cost increase which is mostly earned from Italy Export, specifically from Portugal and Central East market which annulled savings from other export market.

To get the Grand total percentage, the cost changes from all countries are summed and divided by the total annual transportation cost. The Grand total percentage earned from calculation is 0.18%, which is actually very small since the calculation covers a very large portion of Barilla's sales. To put the grand total percentage, it is actually very close to the total savings of Austrian local sales (6.1%) and Sweden Export (1.5%) combined or just enough to cover 22% of the cost increase in the export sales.

II.   Non-Palletized items

To put things into perspective, 88% of the goods are sent palletized while another 9% are sent without pallet or unpalletized. Thus, the turnover of the goods in this section would not be as many as the palletized section. The extent of customers that do not accept pallet also very low, with mostly customers located very far away from the sourcing plants of warehouse. The absence of pallet also is mostly to minimize the risk of insect contamination during long travel and help Barilla to ensure the quality of the products which are sent to the customers.

The markets which receive unpalletized goods and integrated into Headquarters' system are mostly under two countries of Sales Organization: Italy and Singapore. In total there are 5 Sales Organization: Italy Intercompany, Italy export, Singapore local, Singapore intercompany and finally Singapore export. Therefore, the results would be presented on the same graph. Due to confidentiality of the data, the results would be presented in percentage. The bigger the percentage does not directly mean that it is the most impactful to the total result as each Sales Organization has different total annual cost, thus, would affect the total result differently.
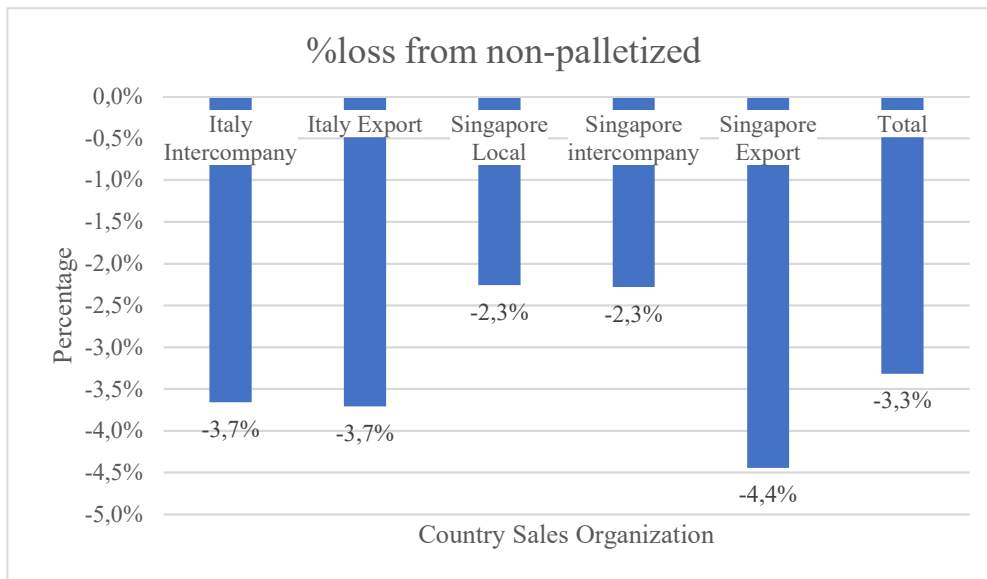
Figure 98. %Transportation Cost Increase of Non-Palletized items

Figure 98 shows the difference between total subtraction of old [M3/year] and the IMU [M3/year] multiplied with the cost rate of [€/M3]. Thus, a negative value means that with IMU, there is an increase a volume, given the same weight turnover/year. As shown on Figure 98, Italy Intercompany sales organization would have a cost increase of 3.7% and Italy Export would have a cost increase of 3.7%. Singapore local sales, intercompany and Export would all receive cost increase by 2.3%, 2.3% and 4.4%; respectively. Overall, non-palletized items would have a cost increase by 3.3%. Upon observation, it is found that the increase of volume is resulted from the increase of dimension saturation. Since the old items did not fully saturate one pallet volume, it is easier to put more items in one cubic meter upon after the pallets were removed. After the switch, IMU versions would only receive a reduction of height after the pallet is removed, whilst keeping their length and width to or close to 1200 mm and 800 mm as they have better dimension saturation of a pallet.

To understand better how the IMU switch affects the goods arrangement of unpalletized items, an example on Brazil and Mexico is taken. Both countries receive orders in either container 40 ft or container 20 ft but there are 2.6 40 ft containers for every 20 ft containers; making 40 ft a preferable mode of transportation to reach these 2 countries.
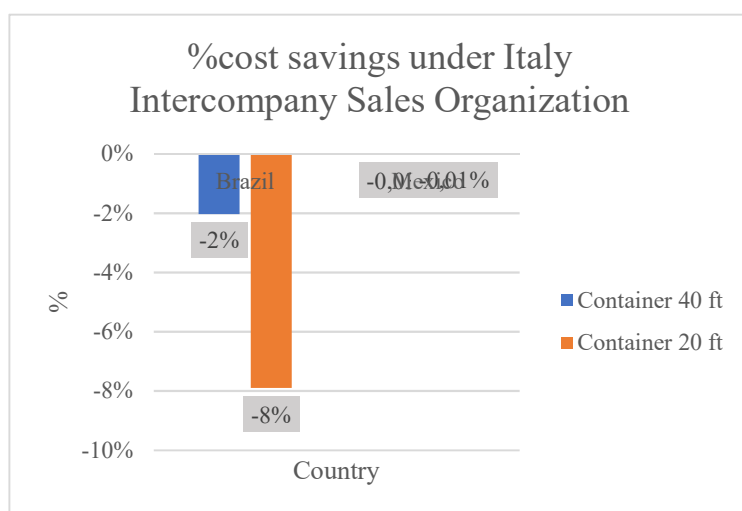
Figure 99. %Transportation Cost Savings under Italy Intercompany

When goods are shipped without pallet, it does not mean that these goods are not stored on pallet. In fact, these goods remain on pallets when kept inside the warehouse and when an order arrives, the warehouse worker simply removes the pallet, keeping the items in the same arrangements with the same numbers of trade units and consumer units. The difference, however, can be spotted when these orders are loaded into containers. Despite having a fix area of a European standard pallet when stored on warehouse, these IMU versions have areas based on how they saturate the area of the pallet when loaded on containers. If an item saturates completely one pallet area, it means that the goods would accommodate one pallet place but when not, it only occupies a certain amount of area which is less than a pallet place.
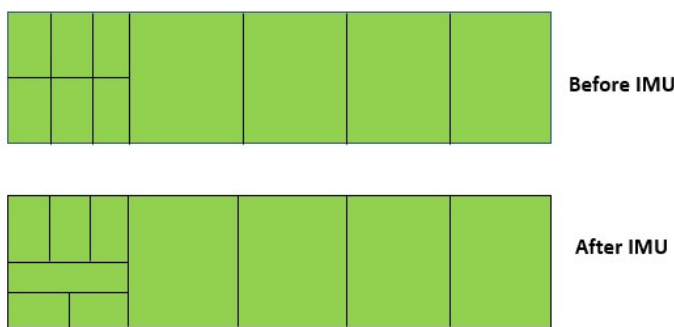
Figure 100. Segmentation in a 40-ft Container

Since IMU versions are designed to saturate the pallet volume better, they also saturate the area better, which means each of the goods sent without pallet would also accommodate one pallet place. While this seems to be a good improvement, it turns out that the way Barilla segments its containers rely on these unsaturated, less-than-a-pallet-place goods which means that If these goods now saturate an entire pallet place, Barilla may put less pallet in each segments. The arrangements of pallets inside a 40 ft container is demonstrated in the graph in the left.

Before IMU, a 40-ft container would be segmented in 5 segments, in which there are 6 spots to load goods without pallet. This arrangement is made possible because the old versions usually do not saturate fully an area of a pallet place and for those who do, there are others which are smaller and these two can be paired into one segment to satisfy the arrangement. After IMU, all goods saturate the area of a full pallet, making it impossible to pair and build the same arrangement before IMU. Thus, the arrangement is change from 6 spots in 5 segments to 5 spots in 5 segments as pictured. With this second arrangement, the maximum number of pallets in a 40-ft container decreases from having 60 pallets in 2 layers to 50 pallets in 2 layers. This number of pallets is the maximum, but this arrangement must still respect the maximum 24 tons and 67 m3 in a 40-ft container.

When combined, the total transportation cost between palletized and non-palletized items receive an increase of 1.1% from last year's annual transportation cost. The cost increase from the non-palletized items is bigger compared with the cost savings from the palletized items which results in a loss. In a glance, it seems strange to have a cost increase while having less pallets to be

transported. However, it is important to note that each pallet has different cost rates depending on, as mentioned before, 3 major aspects: the country of origin, the destination country and the type of loading modules. Therefore, one pallet increase may worth more than others, as well as the decrease.

G.   Storage Cost Evaluation

Storage cost is another cost recorded by Logistics department only that it is not recorded in a cost rate such as [€/ton]. Instead, Logistic department records the complete cost associated with running the warehouse and the total pallets managed by the warehouse in a period. To get the storage cost driver, these two values were taken and used to calculate the average warehouse cost per pallet.

$$Storage\ cost\ rate\ \left[\frac{€}{pallet}\right] = \frac{Total\ storage\ cost\ [€]}{Total\ stock\ [pallet]}$$

Equation 6. Storage cost Rate Formula

Storage cost is another logistics cost that can be calculated after the pallet change analysis. The   difference between transportation cost and storage cost is that transportation varies depend on 4 major aspects while storage cost only in one, which is the warehouse where a pallet is stored. Thus, in calculating the warehouse cost of one specific warehouse, it is required to sum all the pallet differences which have been stored in the warehouse across all regions, then to monetize it by multiplying it with the storage cost rate. The storage cost rate can be found by applying filters on SAP as follows

- Controlled variable
    - Time
- Independent variable
    - Plant
- Dependent variable
    - Total storage cost [€]
    - Total stock [pallet]

$$Potential\ savings\ \left[\frac{\Delta pallet}{year}\right] * cost\ rate\ \left[\frac{€}{pallet}\right] = \boldsymbol{Potential\ savings}\left[\frac{€}{year}\right]$$

Equation 7. Potential Savings on Warehouse Cost

The results vary among warehouses, as the warehouses which would receive less pallets when IMU arrive, would have a cost saving while at warehouses which receive more pallets, a cost increase is to be expected. Figure 101 shows the pallet change in warehouses with considerable

pallet changes while the other warehouses with only very few pallet changes or would not be used anymore are not considered. The warehouse with most pallet reduction is Foggia with -16% from IMU implementation while the most increase is Kuehne&Nagel with 2%.
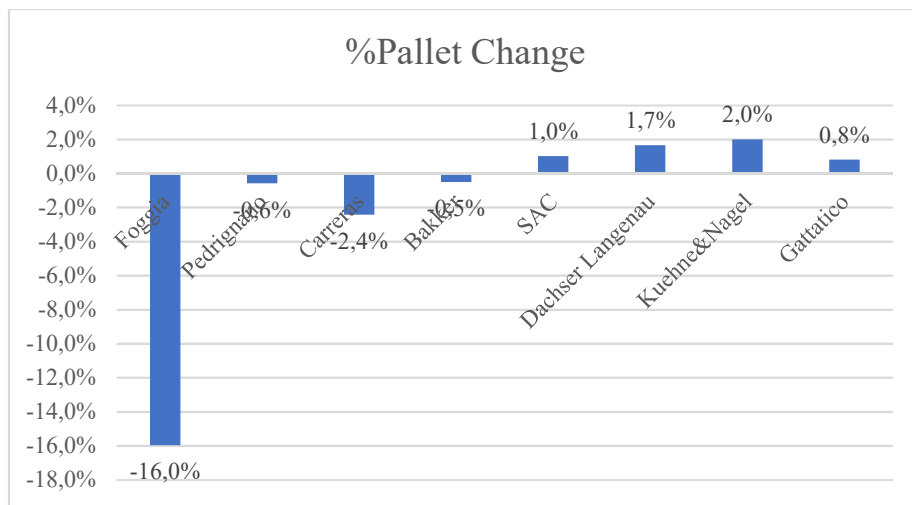
Figure 101. %Increase of Pallet of Warehouses After IMU

By multiplying these increasing pallet numbers with cost rates, the cost increase associated with the new pallet numbers is obtained. Although having the most pallet change compared with its last year's pallet turnover, the storage cost rate of Foggia is not that high. Thus, the 16% additional pallet would only result in 16% cost increase or loss. Meanwhile, Carreras, a warehouse in Spain would only receive 2.4% increase of pallet numbers but the warehouse apparently did not operate with high cost, making this 2.4% increase of pallet numbers impactful enough to add 45% of its total warehouse cost.
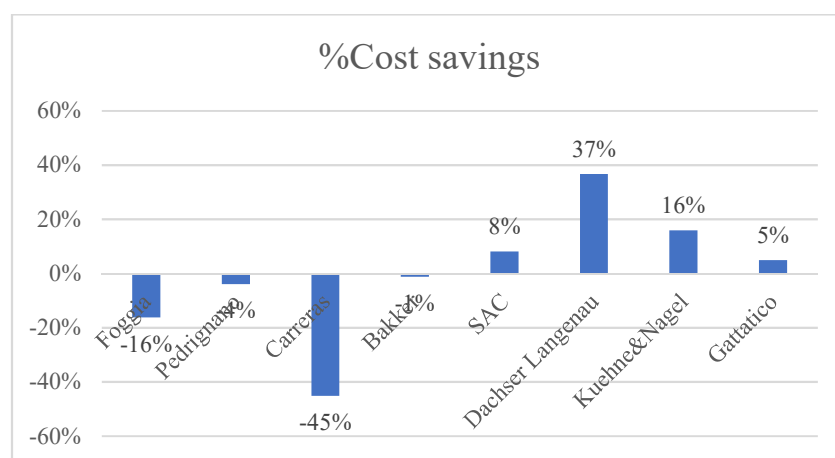
Figure 102. %cost increase of Warehouse Cost

Overall, the arrival of IMU versions would bring a potential to save 3.9% of last year's total warehousing cost of Barilla's warehouse which comes from 0.36% of pallet reductions. This value is a contradiction to the transportation cost analysis due to the fact that the transportation cost is calculated on the item level using the pallet difference of each item before and after IMU, having the same weight turnover. For the warehouse cost calculation, however, the calculation is done on the warehouse level which means that the aggregate of pallet difference from all the items in the warehouse is calculated and the final pallet difference is calculated with the cost rate of a pallet place of the respective warehouse. it is important to remember that transportation cost calculation has more cost rate variations which all valued one pallet differently and that the warehouse always use pallet to store the goods.

H.   Stops of Repacking Activities Cost Evaluation

The arrival of IMU versions also create a possibility to use them as replacements of old repack versions. Previously, some countries repack some of their items into Shelf ready packaging locally, multipacks or bundles or finally into display units. These repacks are made locally because Barilla could not produce specifically for each customer and it is more profitable to subcontract the activity to subcontractors or referred as copackers which are selected by local customer service or logistics. The presence of the IMU versions would allow the local representatives to stop the contracts with local copackers and directly use the IMU versions because the previous repacking activities such as the creation of multipacks and local SRP can now directly use which are produced from plants and the old display units which required secondary packaging material could be replaced by stacking the IMU trays.

Another activity that may be affected by IMU versions are stickering activities. There are two types of stickering: "legal" and "price". The legal stickering are attached to each consumer units as required by local government or regulations to explain the contents, importer name and other information to allow local customers to understand what they are buying while the price stickers are attached when a chance of price on bundles is given as a promotion or other reasons. Stickering activities may be affected due to the fact that a copacker needs to open a trade unit box before stickering each consumer units and rearrange them back to the trade unit box. If the trade unit box changes, there would be change in time which affects the labor cost. The old trade unit box is harder to open but it is easier to be closed while the IMU box is easier to be opened but is harder to be re-closed well. The old trade unit boxes use classic American boxes which can be opened only from the top while IMU boxes have 2 parts, the tray and the cover. To open IMU boxes, it is enough to pick

the cover, sticker all the consumer units inside and reattach the cover to the tray by using glue while opening old American boxes would require scissors to cut all the tapes and once done, a copacker needs to tape the top once more. This change of activities, while still maintaining the stickering material cost would affect the time which influences the labor cost.

These changes might create benefits or disbenefits for Barilla. Thus, an analysis is carried out using three different terms: Cost increase, Cost savings and Cost avoidance. Cost increase is a disbenefit which may come from the use of IMU versions. IMU versions may create additional cost since if it has been opened, a glue is needed to seal the surroundings and ensure that this glue is placed correctly so that the product can be handled safely while the old American case can be directly sealed with a scotch tape at the top without the risk of breaking the bottom part. Meanwhile, cost savings is a benefit from IMU versions when a cost that has been had previously can be stopped after the arrival of IMU and Cost avoidance is a benefit from IMU versions when a cost in the future can be avoided after the arrival of IMU versions. The cost factors that are considered in the calculation are mainly in two categories: labor cost and material cost. Labor cost links to the added activity that would affect the time to open the box and relates to labor productivity and capacity while material cost relates to cost of printing the sticker which would be attached to the consumer units if needed.

These costs are differentiated in order to help with the analysis and the final assessment of the benefits and disbenefits. The analysis is an as-is-to-be analysis. Thus, 2018 turnover of the items are used to calculate the benefits or disbenefits in 2019 for 52 weeks starting from the day the items switch to IMU. The formula used is as follows:

$$Cost\ change\ 2019: Turnover\ 2018 \left[\frac{Tons}{year}\right] * \frac{(52 - switch\ week)[weeks]}{52 \left[\frac{weeks}{year}\right]}$$

$$* (old\ repacking\ cost + material\ cost) \left[\frac{€}{ton}\right]$$

$$Cost\ change\ 2020: Turnover\ 2018 \left[\frac{tons}{year}\right] * \frac{switch\ week\ [weeks]}{52 \left[\frac{weeks}{year}\right]}$$

$$* (old\ repacking\ cost + material\ cost) \left[\frac{€}{ton}\right]$$

$$If: additional\ cost\ after\ IMU \rightarrow Cost\ increase$$

$$less\ cost\ after\ IMU \rightarrow Cost\ savings$$

$$Evade\ additional\ cost\ after\ IMU \rightarrow Cost\ avoidance$$

Equation 8. Formula for Cost Increase, Cost Savings and Cost Avoidance

The process starts by creating a list of repack items of each countries along with the types of repacking activities of each item. Then, the items on the list are confronted with IMU switch plan to know whether a specific item would receive IMU or not. The items which would not have IMU versions would not be considered. Finally, the list with items which would receive IMU versions is confirmed by contacting local customer service representatives of each region whether the arrival of IMU would result in cost savings, cost increase, cost avoidance or may also be nothing. The final list of items within the calculation is as follows:

Category	Country	Number of Repacked items each country
Display	Finland	1
	France	6
	Germany	2
	Poland	3
	Spain	5
	Sweden	2
	Switzerland	1
Multipacks	Spain	5
Multipacks+Stickering	Japan	1
SRP	Adriatic	10
	Netherlands	10
	Norway	4
	Poland	8
Stickering	Japan	10
	Russia	3
	Switzerland	5

1. Stickering

As mentioned before, items with stickering may have change depending on the time difference between opening and closing of old boxes and new IMU boxes. Local customer service representatives for Japan, Russia and Switzerland were contacted and shown a video on how to

perform stickering on items inside IMU boxes. After that, these copackers were asked if they would value the process differently and would they charge a different cost on each item after the switch. In Japan, there 10 items which were stickered before IMU but after IMU arrivals all would be cancelled not because of IMU but because the clients would stop ordering them. Therefore, no additional cost is addressed in Japan. In Russia, there were 3 items that would still be repacked after IMU. Russia does not have a copacker and everything is done inside Barilla's warehouse. Thus, there would not be any additional labor cost after stickering. Finally, in Switzerland, the 5 items would remain be stickered after IMU. Different from 2 other countries, there is an additional cost for the stickering for Switzerland with an increase of reworking cost due to an increase in complexity of closing and opening the IMU cases.

2. Multipacks+ Stickering

The multipacks in Spain do not receive any advantages from IMU. When contacted, a local customer service representative stated that there were not any talks in profiting from IMU cases. Thus, no savings would be addressed in Spain. In Japan, however, there is an item remains that would be stickered and multi-packed. While the cost of creating multipacks would not receive any increase in cost as communicated before, the stickering would result in an increase of cost due to the complexity of using glue and reclosing the trade units after all the consumer units have been stickered. The increase was actually only for the stickering material cost, but a differentiation between the stickering material and the stickering labor could not be distinguished.

Figure 103. Multipacked +Stickered item

3. Local Shelf Ready Packaging (SRP)

There were 4 markets which previously had locally made shelf ready packaging: Adriatic, Netherlands, Norway, and Poland. All these countries benefitted from the arrival of IMU versions. Adriatic, Norway and Poland would stop any repacking activities immediately when IMU versions arrive while the case of Netherlands is a little bit complicated. The Dutch market demands the production of mono-facing cases to be able to introduce to its customers while it is not yet confirmed to be produced directly from the plant. The constraint in the production is that the production of

mono-facing is slower and thus affects the production capacity of the plant. Until the production of mono-facing is confirmed, the mono-facing should be repacked locally by local copacker in the Netherlands in order to provide the customers with mono-facing IMU.

Figure 104. Locally created SRP

4. Display Unit

The display units are probably the most difficult repack types to be calculated. These display units used to be constructed by buying additional stands which would then be filled with consumer units and then loaded on a pallet. The display unit is either a ¼ pallet or a ½ pallet. After IMU arrivals, countries which decide to profit from it would use directly construct the display units using the IMU trays, after removing the covers. This means that there would be differences in both secondary packaging material cost and the labor cost which would affect the analysis. Until this study is finalized, the cost of old display units have yet to be defined while the new ones have, which result in an exclusion of most of the display units considered in the IMU switch plan.

Figure 105. Locally created Display unit

Since the number of cost increase, cost savings or cost avoidance cannot be included due to confidentiality, the results are presented in percentage against total transportation cost to help the readers to compare the cost change from the stopping of repacking activities and logistics improvement. Figure 106 shows that overall, despite some additional cost, the savings from stopping the repacking activities equal to 0.9% of Total Transportation cost of the last 12 months. According to Figure 107, This value mostly comes from Savings in 2020 which is higher because most switch happened during the last quarter of 2019. Thus, any savings is recognized in 2020.
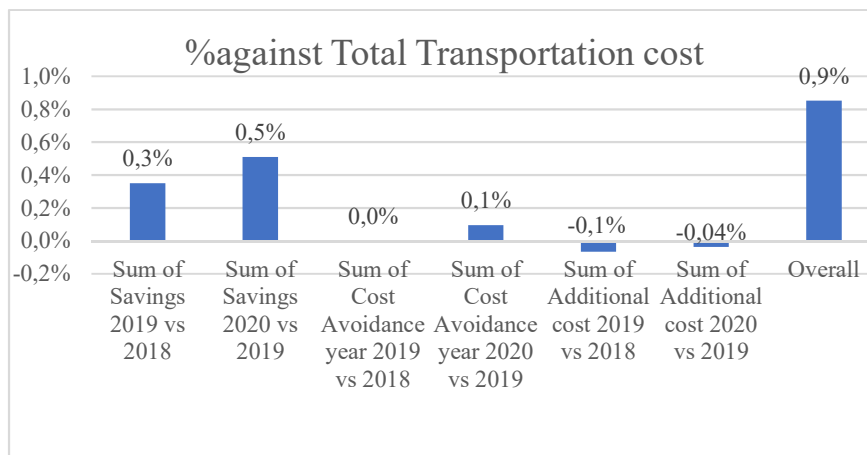

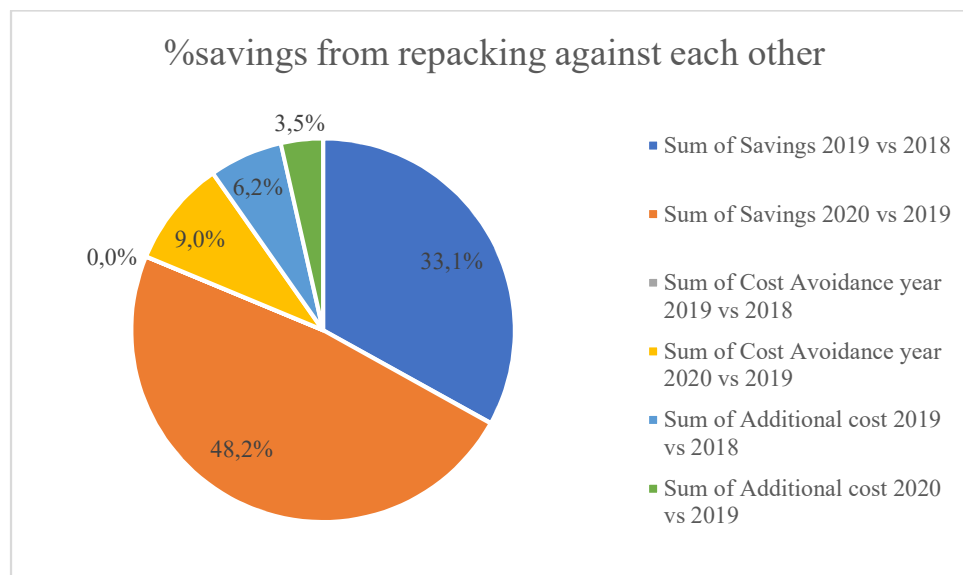*Figure 106. %Savings from Stopping Local Repacking Activities (against Total Transportation Cost)*

Figure 107. %Savings from Stopping Local Repacking Activities Against Each Other

Until this study is submitted, the calculation has not covered all items due to the problems with mapping the old labor and packaging cost of display units and the fix date of Mono facing items Netherlands. Thus, the result presented is true until week 31.

1. An Example on IMU Switch Effect for VMI customers

To better understand the difficulties during switch, an example on Vendor-Managed Inventories customers is presented. These customers would remain anonymous due to data confidentiality but are chosen as an example because the information on their warehouse is available in Barilla's SAP. There are 6 important KPIs to be monitored to understand what happen during Switch. The first important KPI is the **#SKU in warehouse.** The number of SKU would affect how a warehouse is managed because selectability is important. It is impossible to put two or more different items on the same drive-in. The second important KPI is the **Pallet capacity** of the warehouse. By analyzing how the arrival of IMU affects the number of pallets in the warehouse, it is possible to understand whether there should be a problem or not. The third important KPI is the **Days of coverage.** The day of coverage is calculated by dividing the level of inventory or number of pallets with the number of items sold or sell out to shops from Distribution Center. When the IMU items were stocked and not sold, the days of coverage becomes infinite due to the formula. It is important to observe whether the arrival of IMU would affect the days of coverage in the warehouse. This KPI would be presented in average per week as each item has different consumption rate and interchangeable. The fourth KPI is the **percentage of Order Fill rate (%OFR).** This KPI needs to be measured to understand whether the switch is done smoothly to ensure that the customer's warehouse is able to keep replenishing its shops despite the switch period. The last KPI to be observed is the **Stock out which is related to OFR**. If IMU items arrive too late, the stock out would be high but if they arrived too early, they may affect the number of pallets in the warehouse and days of coverage.

By observing these 5 KPI, it would be possible to get the picture on how the switch affected the customers. It is expected that such switch would not influence any problems in the customers' warehouse, moreover on the customers that are in the VMI program. The results would not be presented for every VMI customers. Instead, a real data of one customer which represents all other customers are presented. Since the goal of the VMI is to provide the items just when needed, the movement of stocks would be really fluctuated which reflects the seasonality. Therefore, the KPIs observed are those of switching weeks compared with the last year's KPI for the same duration.

i.   #SKU in Warehouse

The number of SKU in the warehouse affects the selectability of the warehouse. It is important to note that any increase would not directly mean that the switch creates problems since the real warehouse capacity is not known. An increase of SKU number when compared with that of 2018

should simply be treated as a warning to be observed. The observation on the number of SKU in the warehouse in 2019 is presented on Figure 108 below
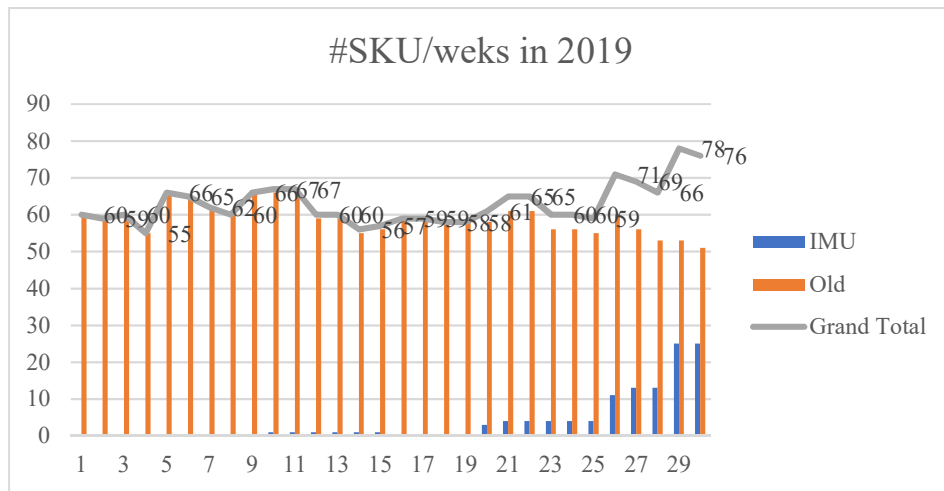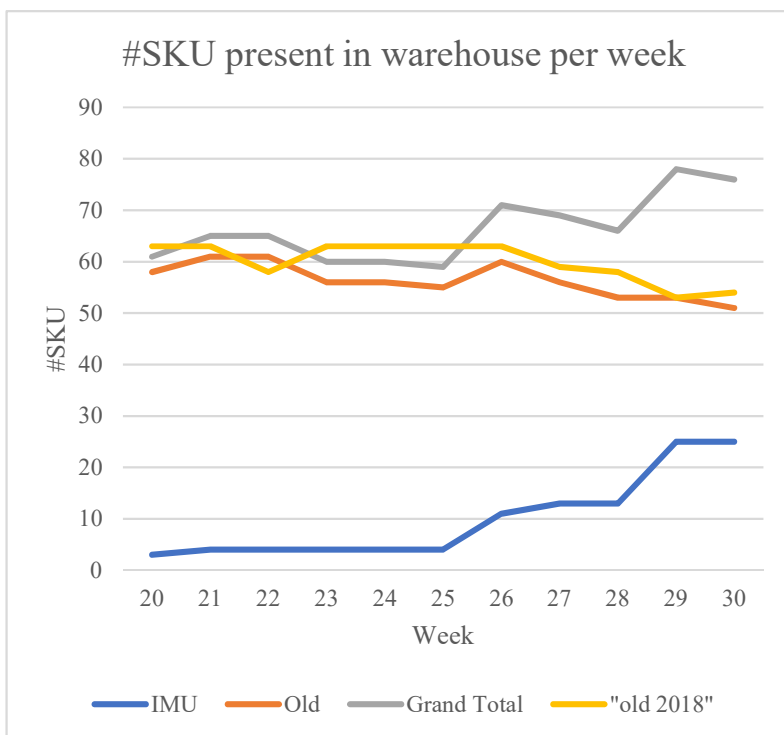

Figure 108. Weekly #SKU of a Customer in 2019

Since the data is not normally distributed, it is impossible to use standard deviation to analyze the whether the new set of data has changed the data population or simply within the margin of error. To analyze this, a histogram is created with a certain data range to understand how the values change around the average. The values analyzed into the histogram are only those of switching weeks since a variation may be caused by seasonality.

Figure 109. #SKU during switch weeks 2018 vs 2019

For this customer, the switch happened on week 20 until the most current time during data extraction, week 30. The average number of SKU in week 20-30 in 2018 was 60, the same with the average in week 20-30 in 2019 after the switch. Meanwhile, the average of old items only in week 20-30 2019 is only 57. While the averages of 2018 and 2019 after the switch are the same, it does not

mean that there are no changes due to IMU switch since the variations around these averages are not known. Figure 110 below shows the variations around the averages.
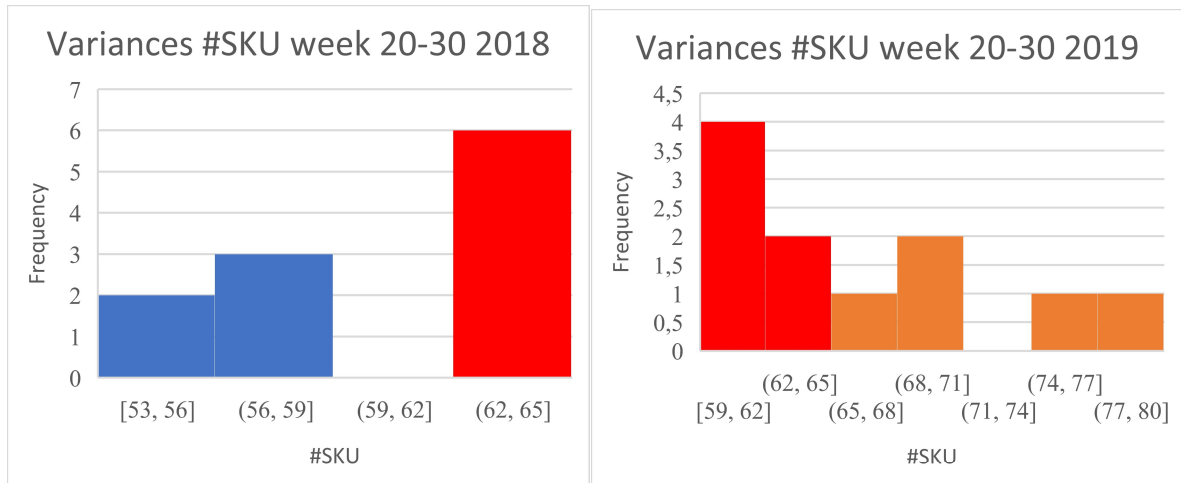

Figure 110. Variance of #SKU in 2018 vs 2019

In 2018, 54% of the time, there were 62-65 numbers of SKU in the warehouse while for the other 46%, the numbers of SKU were below the average. In 2019, 54% of the time, there were 59-65 numbers of SKU, but the difference is that the other 46%, there were more SKU than the average of 60 SKUs in the warehouse. These different distributions explain that although both years had the same averages, IMU switch tend to move the values up which means that there is a significant increase of SKU number during switch weeks.

ii.   #Pallets in warehouse

Figure 111. Weekly Inventory level in Warehouse 2019
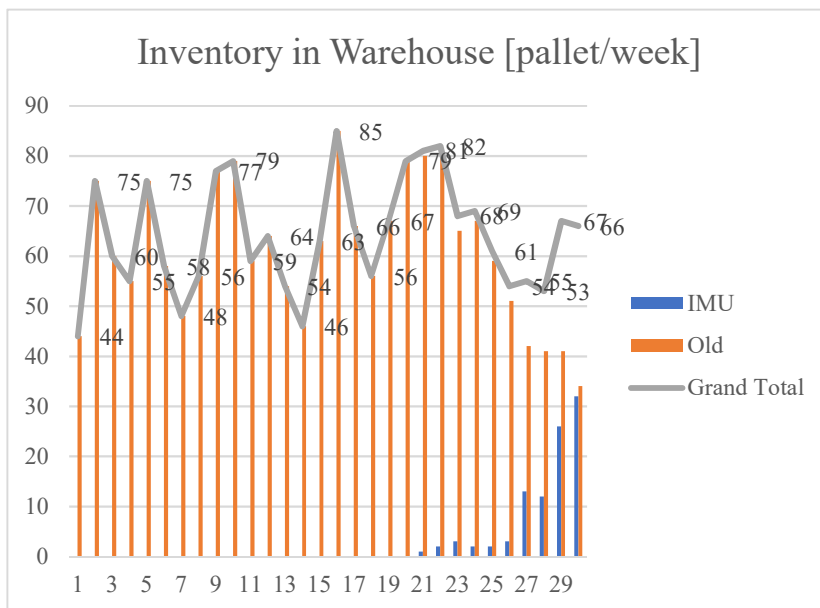
The number of pallets is important to be observed to ensure that the arrival of IMU versions do not cause overcapacity in the warehouse. Barilla started sending the IMU versions prior to their selling in order to avoid stock out. These IMU versions were stocked until the stock of the old versions had completely depleted and the customers could change the codes in their system.

As seen on Figure 111, the number of pallets is fluctuated and to eliminate seasonality, the number of pallets during switch week were highlighted on Figure 112.
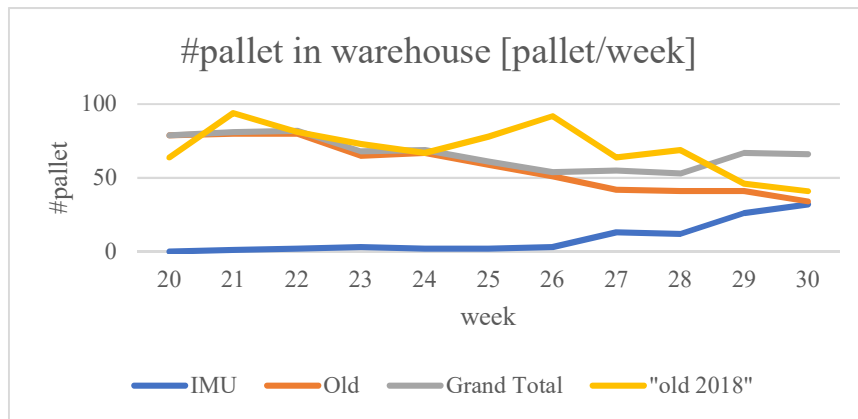

Figure 112. #Pallet in warehouse during switch weeks 2018 vs 2019

During these switch weeks, the average of total IMU and old item was 67 pallets/week while the average of old items was 59 pallets/week. The total average was not so different with that of 2018, which was 70 pallets/week during week 20 to 30. Again, since the data was not normally distributed, the variations around the average could not be defined. Thus, a histogram is created to understand how the values revolve around this average.
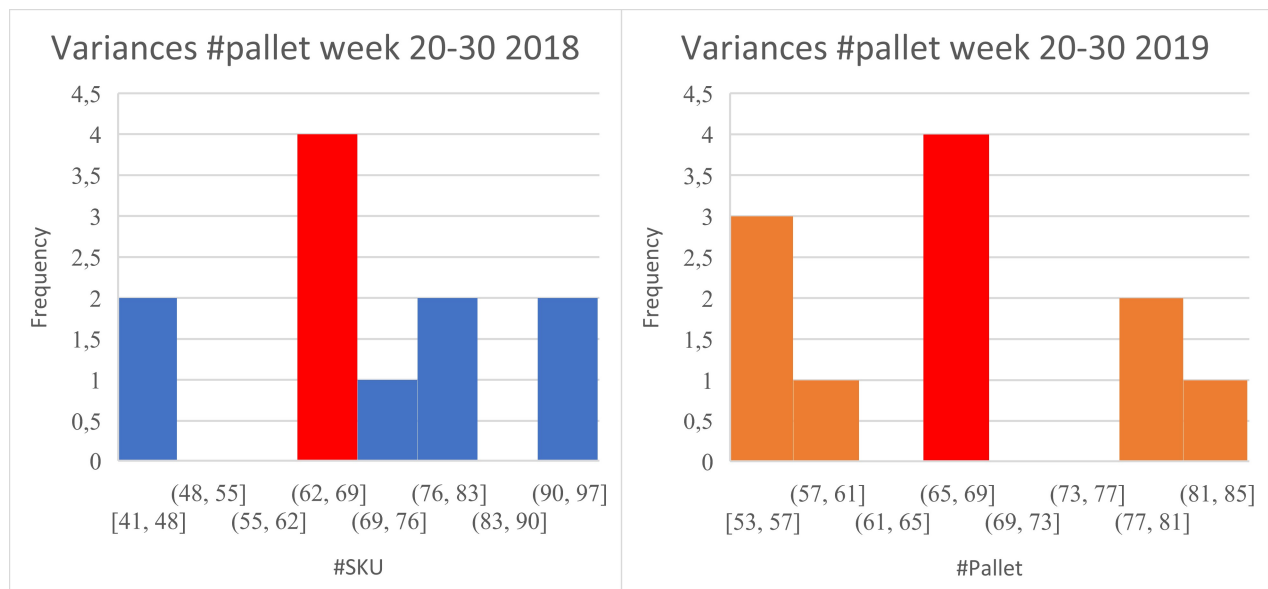

Figure 113. Variance of #pallet 2019

From the histograms, it is clear that in 2018 there were more variances in pallets/week ranging from 41 to 97 pallets/week while in 2019 only from 53 to 85 pallets/week. In 2018 also the number of pallets tend to spread over the average while in 2019 under. This result shows that there should be

no problem in warehouse capacity since the warehouse had handled more pallet number/week before in 2018.

iii.   Days of Coverage

This KPI is different from the previous 2, since the previous 2 were collective KPIs which can be summed together to get an overview of the warehouse capacity while the days of coverage are different for each item depend on the customer's consumption rate of each item. Some items may have the same pallet number in the inventory but translated into different days of coverage because of different consumption rate. Since this KPI is different on item level, days of coverage of the warehouse equals not to the total days of coverage of all items but the average of days of coverage of all items in the warehouse in the specific week.
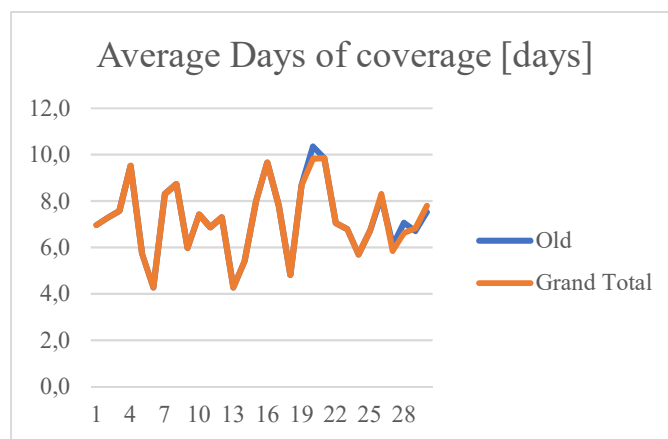

Figure 114. Average days of Coverage in 2019 Just Old vs Grand Total with IMU included

Since these values are already average, it is not recommended to do another average for the whole year but comments can be made by analyzing the change on the average days of coverage. By comparing the days of coverage of only old items and the whole items including IMU versions, the average warehouse days of coverage did not seem to be affected. During the switch weeks 20 to 30, it can be seen from the figure 115 below, the days of coverage of IMU versions seemed to be very fluctuated and although they were present since week 20, they were sold starting in week 24. Meanwhile, the average days of coverage of the warehouse (below in grey) seemed to fluctuate around the same numbers with no extreme changes seen from the Figure 115.
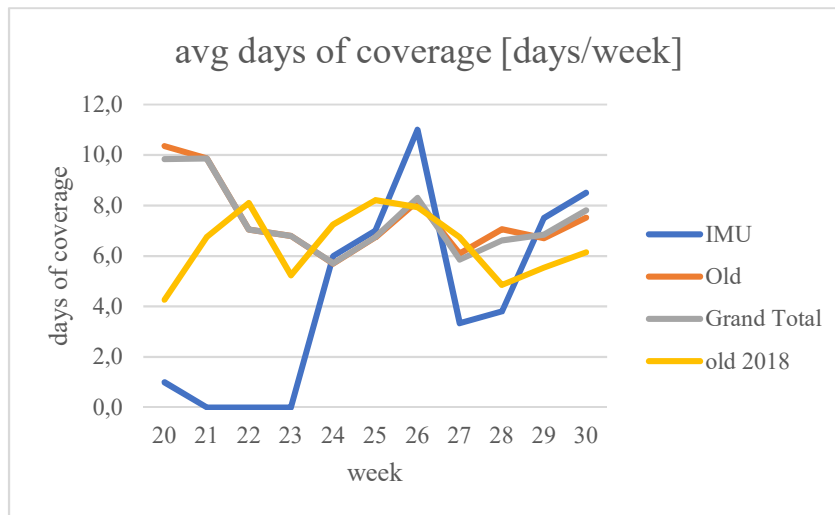
Figure 115. Average Days of Coverage During Switch Weeks

While the line graph explains well how the average days of coverage of only old versions compared with total IMU and old items, it does not explain the different averages between 2018 and 2019. For this reason, histograms are used to compare these averages.
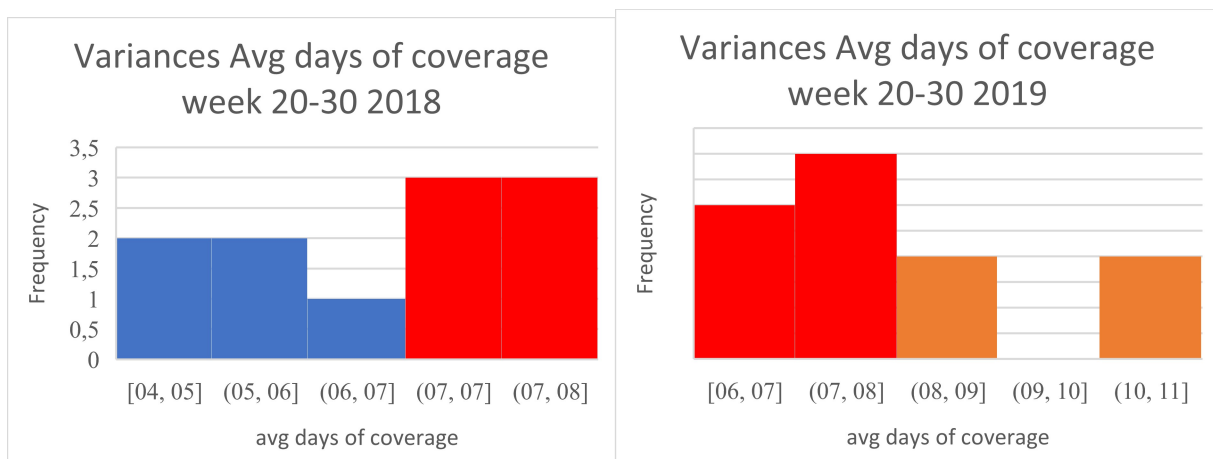

Figure 116. Variance on Average days of Coverage 2018 vs 2019

From the histograms, the average days of coverage in 2018 are between 4 to 9 days while in 2019 between 5.7 to 10.7 days. Overall, 2019 has more days of coverage compared with 2018 as 64% of the averages fall between 5.7 to 7.7 days while the rest are over 1 week of coverage. On the contrary, 55% of the averages in 2018 fell between 6.7 and 8.3 while the rest fell under 1 week of coverage.

iv.   Stock Out

The stock out exists in the analysis only when there are items which do not have any days of coverage left and thus, a customer suffers a period of time without those items in his shelves. This stock out is important to be monitored as due to IMU switch, the customer must register the new versions just before they were to be sold and not before or after. The Stock out measures the misalignment of

91

information between Barilla and the customer. As shown on Figure 117, the customer does not suffer any stockout during switch weeks. This zero stockout means that Barilla manages to keep to stock of customer's warehouse in a level that he can always replenish its shelves.
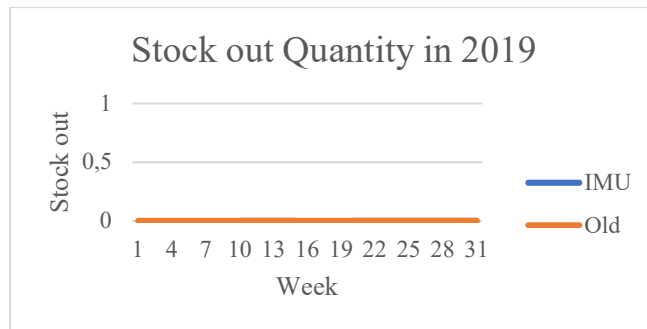

Figure 117. Stock Out during Switch Weeks

To help understand how the switch happens, the movement of Trade units of an item is highlighted. From figure 118, it is clear that the downhills at week 7 with 30 packs, week 11 with 37 packs and week 16 with 24 packs are the weeks when the customer would replenish its shops. On the fifth replenishment of the year, on week 26th, instead of replenishing with old versions, the customer replenishes with IMU version which the customer would start selling on week 38 with the old version finally out of stock on week 39. It is important also to see that there are always 3 weeks difference between the top of the hill and the bottom during all four first replenishment which explains that the lead time of replenishment is every 3 week for this particular item to this particular customer. The same thing when the switch happened on week 26, it can be seen that the old version finished its stock on week 39, exactly 3 weeks after the customer started replenishing with IMU version.
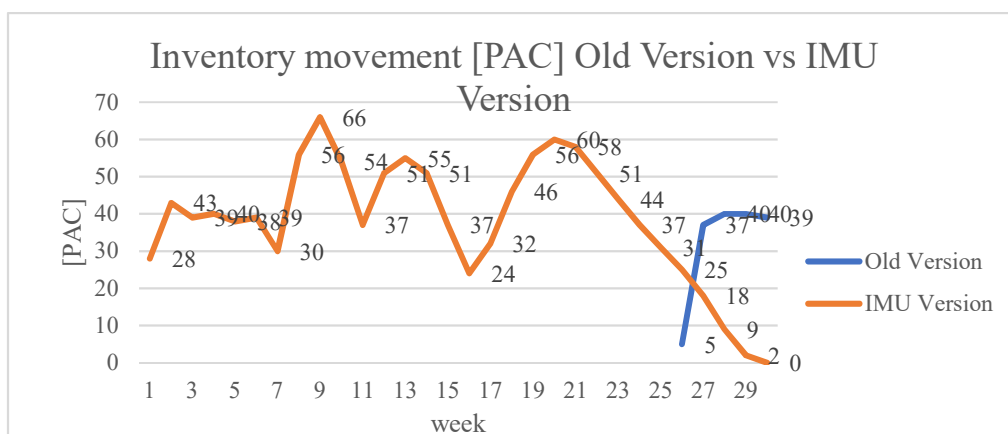

Figure 118. Trade units movement of Old vs IMU version

v.   Percentage of Order Fill Rate (%OFR)

The percentage of Order fill rate shows the capability of the customer's warehouse to keep replenishing the shops assured by the correct stock management of VMI. From the table below, it is

shown that despite the switch, the customer's warehouse has always successfully replenished its shops with the required item on time. When the %OFR is 0, it actually means that no replenishment is performed that 0 which also mean 0 stock out.
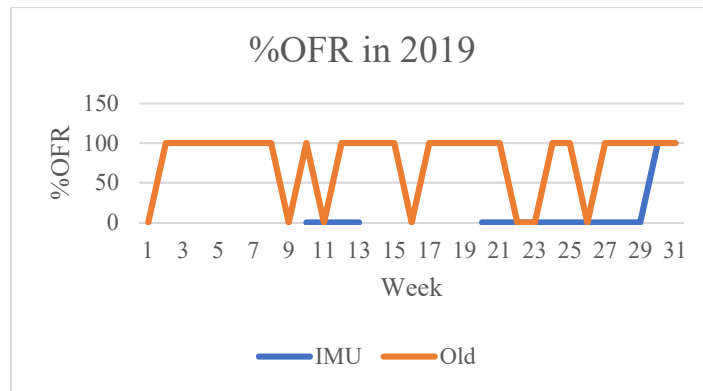

Figure 119. Percentage of OFR during Switch weeks 2019

VII. Conclusion

Following 8-month Internship in Barilla and closely involved in Intelligent Modular Unit (IMU) project, calculations are made based on real data and conclusions are reached. The conclusions are as follows:

1. The IMU versions developed under IMU project gives modularity to items sold by Barilla in all regions. The trade units of all items receive better length, width and height saturation although this pursue of modularity sacrifices the number of cases in each trade units with a weighted average of case reduction of 7.6%.

2. The increasing saturation would increase the specific weight of a pallet but since an increase of saturation might be followed by a case reduction, the kg/pallet of IMU versions and old versions are compared to find any increase or decrease in annual pallet numbers. The result shows that with the same weight turnover of the last 12 months, Barilla would have -0.36% less pallet than when selling old versions.

3. The decrease of annual pallet turnovers creates a saving of 3.9% on warehouse cost but a loss of -1.1% of transportation cost. When combined, the switch of IMU only results in 0.05% of cost savings in logistics cost before incorporating any additional investment cost. The loss in transportation cost has different result with the warehouse cost due to the fact that transportation cost is calculated on item level while the warehouse is calculated at the base of the warehouse with the total pallet difference in a warehouse multiplied by the cost rate of storing a pallet place in the respective warehouse.

4. From packaging department point of view, arrival of IMU versions creates savings due to the possibility of terminating local repacking activities. This termination due to IMU creates saving equal to 6% of Pedrignano warehouse cost in 2019 and 8% of Pedrignano warehouse cost in 2020 mostly from Japan. To make the result comparable, it equals to 0.9% of the transportation cost.

References

[1] E. E. ECR Europe, «Shelf-Ready Packaging: a comprehensive guide for a collaborative approach,» ECR Europe, Brussels, 2016.

[2] ECR Europe, «Optimal Shelf Availability,» Efficient Customer Response & Roland Berger, Brussels, 2016.

[3] B. G. Barilla, «Annual Report 2017,» Barilla Group, Parma, 2017.