Improving the Cash Availability of Small Firms in Latin America via Better Inventory Management

by

Analiz Cabrera Hernández

Bachelor of Science, Industrial Engineering, Tecnológico de Monterrey, 2010

and

Trevor Nathan Thompson

Bachelor of Science, Supply Chain Management, Arizona State University, 2016

SUBMITTED TO THE PROGRAM IN SUPPLY CHAIN MANAGEMENT
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF APPLIED SCIENCE IN SUPPLY CHAIN MANAGEMENT
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

May 2020

Signature of Author: _____

Analiz Cabrera Hernández
Department of Supply Chain Management
May 8, 2020

Signature of Author: _____

Trevor N. Thompson
Department of Supply Chain Management
May 8, 2020

Certified by: _____

Dr. Josué C. Velázquez Martínez
Executive Director, Supply Chain Management Master's Program
Capstone Advisor

Certified by: _____

Dr. Cansu Tayaksi
Postdoctoral Associate
Capstone Co-Advisor

Accepted by: _____

Prof. Yossi Sheffi
Director, Center for Transportation and Logistics
Elisha Gray II Professor of Engineering Systems
Professor, Civil and Environmental Engineering

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ABSTRACT

In Latin America, micro, small, and medium firms represent about 99% of businesses and more than 70% of employment, according to the Organization for Economic Cooperation and Development. Despite their number, these firms face a low survival rate: per the Small Business Administration, only 50% are still in business after five (5) years. We identified lack of cash availability as a driving force behind this high failure rate. There is an opportunity for these firms to achieve improvements in cash availability by managing their inventory better. This is relevant for these firms because they operate on a cash basis, meaning they pay for all necessities with cash and, in turn, collect all payments in cash as well. In this capstone, we present an inventory management framework that focuses on improving the cash availability for micro and small firms via better inventory management. At the start of this project, we conduct a field study analysis with three (3) firms in the city of Bucaramanga, Colombia, to better understand their operational practices. Our field study reveals that every firm indeed relies on cash for daily operations, and that these firms struggle to manage that cash effectively. As a result, we map the financial and operational performance of six (6) firms for ~17 weeks and develop a product segmentation and an inventory framework that reduces average inventory and increases inventory savings by up to ~80%, while also increasing inventory turns per segment. Additionally, we create a "business pulse dashboard" that provides weekly visibility to cash management, focusing on sales, profits, inventory, and expenses.

Capstone Advisor: Dr. Josué C. Velázquez Martínez
Title: Executive Director, Supply Chain Management Master's Program

Capstone Co-Advisor: Dr. Cansu Tayaksi
Title: Postdoctoral Associate

ACKNOWLEDGEMENTS

We would like to thank the following for their contributions to our research:

Dr. Josué C. Velázquez Martínez for the guidance and oversight he provided for this research, as well as his unrelenting empowerment in enabling our success at every aspect of this project.

Dr. Cansu Tayaksi for the guidance and support throughout the development of this research, as well as the personal passion she brought during every meeting.

Students at Universidad Autónoma de Bucaramanga & Universidad Pontificia Bolivariana for their tireless and excellent assistance in both the collection of data from local micro and small businesses and subsequent development of targeted recommendations for those businesses.

Micro and Small Firm Owners who provided us with completely open and transparent access to data from their operations. This research could never have been completed without their assistance, and they stood out for their dedication every single week of the data collection period.

Maria Olivia Hernández and Benito Cabrera for teaching me the value of hard work and the power of having dreams. You have inspired me to always follow my heart and own my voice.

JoAnn Thompson, Randy Thompson, and Luann White for their unwavering support through every phase of our research. You are all a source of constant inspiration and motivation.

Each Other for the endless nights full of laughter, countless challenges we had to overcome, and consistency in driving each other insane, only to become best friends in the end.

We were inspired to pursue this project because of the individual passion we each have for helping others, along with the impact we felt our research could have on the lives of micro and small firm owners. We genuinely enjoyed writing this capstone, very much appreciate all the support given to us throughout the journey, and are confident that our work will not end with this paper. Should there one day be an exhaustive resource for business owners outlining how and when to spend their money, we believe there would be an increase in micro and small firm success stories as well as a corresponding reduction in the number of these firms that ultimately go out of business. That is the future we envision, and the one we are working towards.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CCC: Cash Conversion Cycle

DLS: Dynamic Lot Sizing

ECLAC: Economic Commission for Latin America and the Caribbean

GDP: Gross Domestic Product

JRP: Joint Replenishment Model

MIT CTL: Center for Transportation and Logistics at the Massachusetts Institute of Technology

MSEs: Micro and Small Enterprises

OECD: Organization for Economic Cooperation and Development

SKU: Stock-Keeping Unit

1. INTRODUCTION

Micro-sized businesses have less than 10 employees, small-businesses have between 10 and 49 employees, and medium-sized businesses have between 50 and 200 employees (OECD, 2013). These firms make a large contribution to local economies and provide a majority of the available employment opportunities. According to ECLAC (2010), these businesses represent approximately 90% of all businesses and more than 50% of employment worldwide In OECD countries, including those in Latin America, this impact is even more pronounced: Micro and Small Enterprises, or MSE's, account for approximately 99% of all firms and 70% of the job market (OECD, 2018), highlighting the impact of these firms within the region. In fact, this impact extends to most developing countries.

Despite the large number of these firms and their effect on employability, they are facing a high downturn. About 20% close within the first year after opening, with this number reaching 50% within five years (Small Business Administration, 2018). This raises the question: "what is the primary driver behind these failures?" As identified by micro and small firm owners in past research, several key contributors to this failure rate are: "low access to finance, low access to non-financial inputs, and high cost" (Wang, 2016). Of these three factors, gaining access to finance was identified as the largest obstacle that micro and small firm owners must overcome in order to survive. The leading reason for this financing concern is a lack of cash availability. Without the ability to maximize available funds, firms are unable to pay operating expenses, react to market and supply changes, and reinvest cash in firm infrastructure and operations.

Access to finance comes primarily from two areas:

1) **It can be generated by external entities and investors**: According to research conducted by the United Nations and the Economic Commission for Latin America and the Caribbean, just over 45% of small enterprises in Latin America have access to credit from formal financial institutions (ECLAC, 2015). The amount they are provided as well as the frequency of allowed withdrawals is typically small.

2) **Better business practices:** As many micro and small firms are young (<3 years old) or have inexperienced management, finances can be generated and, more importantly, sustainably maintained with improved business practices (Wang, 2016).

Thus, the ability of micro and small firms to adopt internal business practices that ensure self-funding is critical as such access heavily depends on business owners and not external entities. When considering access to finance, it is important to differentiate large firms with micro and small firms. To do so, we reference the Cash Conversion Cycle (CCC), which represents the time period required to convert cash investments in supplies into cash receipts from customers for goods or services rendered. This is further defined in section 2.2. Several key advantages large firms have in financing their operations, and are derived from the CCC, are as follows (Uyar, 2009).

1) **Delaying payments to their suppliers**
2) **Accelerating payments from their customers**
3) **Reducing the average inventory needed to operate**

As it pertains to micro and small firms, however, they mostly operate on a daily cash basis, meaning they finance all of their operations immediately and using physical cash. Specifically, businesses regularly pay their suppliers as soon as they receive their orders and subsequently get paid by their customers as soon as orders are fulfilled. Combined with their low access to outside funding, they must focus their efforts on maximizing the cash they have on-hand at all times: this shifts our focus to inventory management. As a large majority of funds are typically invested in inventory, managing that inventory more effectively and optimally reducing the amount of inventory necessary can contribute directly to an improved cash flow (Moss, 1993).

In looking for ways to impact cash generation as a source of finance for micro and small firms, this research offers a solution to these firms by providing them with a simplified way to re-think their inventory management practices so that they yield increased cash availability. Specifically, we define an optimized inventory management framework that can be utilized by micro and small firm business owners to reduce inventory and increase cash availability. As part of this study, we introduce a new inventory dashboard for micro and small firm owners that helps them make informed inventory decisions while managing the available cash associated with it.

Additionally,, we identify the attributes per business necessary to calculate the optimal inventory (i.e. demand variability). Ultimately, our framework provides answers to the key questions of "what to order", "how much to order", and "when to order" which maximizes cash on-hand while maintaining service level targets for different inventory types. The framework also provides visibility to the expected financial performance of each decision, such as how cash on-hand can change based on certain inventory decisions. In our literature review, we present several existing inventory models. By themselves, each model focuses on "minimizing cost" versus our goal of "maximizing cash on-hand". Therefore, we use each of them as references in establishing our framework instead of just using them independently.

To conduct this research, we followed four steps:

1) **Identified sources of variability in demand and supply in MSEs**: An understanding of what the drivers of variability are by industry and their relevance on decision making for inventory has been mapped. We also captured the data that needs to be collected to track and predict variability to better manage it via differing inventory management models.

2) **Analyzed cash availability drivers**: We assessed the drivers of cost for Small Firms per industry and the impact of inventory decisions on the cash available.

3) **Created a segmented inventory management framework for MSEs**: We propose a framework that outlines the "must do" and "must think" processes that need to be established. It helps bring answers to questions such as:
   ○ Will inventory management be the same for every type of industry?
   ○ Will it be the same for all products?
   ○ What inventory records do MSE owners need to analyze?
   ○ How will MSE measure the success of the inventory models implemented?

4) **Analyzed success factors:** This includes the identification of behavioral recommendations to successfully implement inventory management practices, where to start, and reasons to change those which resonate with MSE owners.

In this capstone, we first present the findings from past research in Chapter 2. In Chapter 3, we present our methodology for data collection, followed by the analysis of our results in Chapter 4. Lastly, we present our conclusions and suggestions for future research in Chapter 5.

2. LITERATURE REVIEW

With MSEs contributing over half of all business sector GDP and representing almost 60% of jobs in Latin America and the Caribbean (OECD, 2019), it is vital that these businesses perform at or above their potential. In comparison to large firms, it is much easier for these smaller businesses to fail in the short-term, which many do, and long-term sustainability is rarely a consideration due to the many operational challenges they face. In contrast to how large firms tend to use size and established history to overcome ongoing challenges in their daily operations, these firms struggle with many issues unique to their size, including high supplier leverage, extreme competition in small markets, and the expense of product differentiation and innovation (OECD / CAF, 2019).

Despite continued efforts to tackle small business issues as is done in large organizations, it has long been noted that "a small business is not just a little big business" (Welsh & White, 1981). The two function differently, have unique issues and factors for success, and should be managed in different ways according to their situation. Past research has primarily focused on identifying the largest challenges in these firms and utilized a macro problem-solving approach to propose potential solutions, such as improved supply chain practices (Pereira & Paulino, 2018). For our purposes, we are aiming to develop a functional solution to a major supply chain issue plaguing these businesses: cash availability.

In this literature review, we explain how cash availability in small firms is handled today and provide insights on why we are centering our efforts on this particular issue. This section also covers other past efforts, if any, to tackle this issue. We then discuss the topic of inventory management and the cash conversion cycle, exploring how improvements in the inventory management process have a direct correlation with cash availability. Specifically, we will discuss how the utilization of our inventory management framework should result in greater cash availability for micro and small firms in Latin America.

The latter sections will review the current inventory management models in use, which primarily appear in large companies, and then compare and contrast these with how inventory is managed within small firms. We explain why the inventory management models that large organizations

typically utilize may not be fully applicable to micro and small firms and provide a small snapshot of our approach to solving this critical issue.

Due to how important access to cash is for these firms, our next section focuses on the ways in which micro and small firms can acquire cash, and the associated challenges they face.

2.1 Cash Availability in Micro and Small Firms

The OECD has established a Policy Index to monitor the development of Small and Medium Enterprises in Latin America, closely related to micro and small firms. This index analyzes seven dimensions, with one of them as "access to finance". According to this index, Latin America has diversified sources of financing available and a solidified ecosystem of players to meet micro and small enterprise needs; however, major challenges encountered within this dimension are (OECD / CAF, 2019):

1) **Regulations**: Many regulations exist aiming to "protect" business owners when borrowing credits which unfortunately also serve as obstacles to the borrowing process itself.
2) **Lack of finance education:** There is almost no educational assistance available to enable decision-making oriented in developing and growing these businesses.

The above challenges result in micro and small businesses heavily depending on cash generated in their daily operations. In fact, a recent census conducted in Colombia to analyze micro enterprise performance reported that, on average, 75% of micro enterprises use cash as the main transaction method with their consumers, while 60% of business owners do not have an accounting review and keep at least 50% of their savings in cash (ANIF, 2019).

While this study does not focus on the financial regulations challenge, it aims to positively impact the cash availability to maximize investment on development and growth of micro and small businesses by improving inventory management. Ultimately, we aim to maximize cash in micro and small firms, considering key conditions that differentiate them from large firms:

1) **Cash transactions**: Micro and small firm transactions are done in cash on a daily basis.
2) **Credit issues:** Low or no credit sources are available for suppliers and customers.

3) **Technology gap:** There is a lack of technology investments for better business management (Dini & Stumpo, 2018).

By focusing on inventory management, we aim to assist micro and small firm owners in overcoming these conditions. As mentioned, managing inventory effectively is one way in which to maximize cash. With inventory management improvements, we will aid micro and small firm owners in overcoming these conditions. Thus, our focus turns to the cash conversion cycle and how inventory management impacts it.

2.2 The Cash Conversion Cycle and Inventory Management

"The cash conversion cycle represents the time period required to convert cash investments in suppliers into cash receipts from customers for goods or services rendered" (Kroes & Manikas, 2014). The cash conversion cycle calculation is shown in Table 1:

Table 1: Cash Conversion Cycle Calculation (Uyar, 2009)

Cash Conversion Cycle	
Formula: Cash Conversion Cycle = DIO + DSO - DPO	
Financial Topic	**Calculation**
Days Inventory Outstanding (DIO)	(Average Inventory * 365) / Cost of Goods Sold
Days Sales Outstanding (DSO)	(Average Accounts Receivable * 365) / Total Revenue
Days Payables Outstanding (DPO)	(Average Accounts Payable * 365) / Cost of Goods Sold

As defined by Soenen (1993), the definitions for DIO, DSO, and DPO are as follows:

- **Days Inventory Outstanding (DIO):** This is the average number of days that it takes for a business to sell an entire stock of inventory. A smaller number is typically better because it means that a company is selling at a higher rate and turning over stock quickly.

- **Days Sales Outstanding (DSO):** This is the average number of days that it takes for a business to receive payments from customers. A smaller number means that a business is able to collect on all sales and outstanding debt owed to them quickly.
- **Days Payable Outstanding (DPO):** This is the average number of days that it takes for a business to pay off bills or to pay back suppliers. A higher number means longer payment terms and equates to a company holding on to cash for a longer period of time, on average.

Previous studies suggest that the majority of micro and small firms have most of their cash invested in current assets in the form of inventory, which becomes a variable to control to ensure a shorter conversion cycle (García-Teruel & Martínez-Solano, 2007). Furthermore, research conducted by Su (2018) shows evidence that an improvement in the cash conversion cycle can result in improved survival rates for micro and small firms. In order to reduce the days of inventory outstanding and the overall cycle, it is important to define a unique inventory framework that helps maximize the amount of cash available for firms to maintain or increase revenue. This framework is unique in that it targets micro and small firms specifically, with each area of the framework aimed at specific types of inventory or types of business.

As we explore in the next sections, most of the current inventory models have been designed for big firms whose main objective is to minimize cost while leveraging economies of scale. In addition, big firms can negotiate longer payment terms with their suppliers and expedite customer payments to reduce the cash conversion cycle.

In Table 2, we present a view of the average cash conversion cycle in 2019 of the three largest retailers in the world: Amazon, Walmart, and Costco. We decided to put this as an example because the retail industry is known as one of the lowest margin industries and it exemplifies how, despite them being low margin, they still grow. As observed in the table, the cash conversion cycle ends up being negative which suggests that they generate revenue from their customers before they actually have to pay suppliers for the inventory they purchased.

Table 2: Average Cash Conversion Cycle - Largest Retailers in the World

DIO	(+) DSO	(-) DPO	(=) CCC
38	11	54	-5

As we have explained before, this is not possible to do within small firms. This project studies the impact of current inventory models and processes designed for big firms and presents a new approach that will adequate to micro and small enterprises cash needs.

2.3 Current Inventory Management Models

Today, several inventory management models are in use. These models are primarily used by large firms, but some applicability for smaller companies has also been discovered. In this section, we focus on: Economic Order Quantity, Newsvendor, Periodic Review, Dynamic Lot Sizing (DLS), and the Joint Replenishment Model (JRP).

2.3.1 - Economic Order Quantity (EOQ) Inventory Model

According to Harris (1913), the economic order quantity model assumes a cost minimizing objective function while keeping demand stable over an infinite time horizon. Essentially, it assumes that the same amount will be ordered within a specified period of time; thus, one can determine a perfect "economic order quantity" to purchase on a regular basis for each product. The calculation also assumes that both ordering and holding costs will remain constant over time. Both of these assumptions make the EOQ model hard to implement and utilize over time, because it is rare that demand or fixed costs truly stay stable. Despite these faults, however, EOQ is the most historically well-known inventory management model due to its ease of calculation and implementation, and it is widely studied in the literature. It has been utilized by many different types of businesses, such as food retailers (Zeng et al., 2019), remanufacturing and dismantling companies (Kozlovskaya, Pakhomova, & Richter, 2019), and oil drilling companies (Sato & Jauhari, 2019), among others. For a comprehensive review of this model, refer to Nobil, Sedigh, & Cárdenas-Barrón (2018).

2.3.2 - Newsvendor Inventory Model

The newsvendor model is a single period inventory model that assumes probabilistic demand within one specified period, as stated by Arrow et al. (1951). This period can vary, such as being

one month, six weeks, etc. Within this model, a business would order a particular quantity, or Q, at the start of every "period" in which they are ordering.

In this model, there is an "order-up-to" inventory level that is calculated through the model. This is the amount one is going to order "up to" after the end of each period, regardless of how much stock is consumed. According to DeMarle (2019), this model can be risky and is very prone to stockouts as well as overstock because nobody is checking inventory throughout the period - only at the end of the period. Agricultural processing is one industry in which the newsvendor model has been applied (Amaruchkul, 2019) and it has also been used for general new product introduction (Chen, F. et al., 2020). For a comprehensive review of this model, refer to Ji & Kamrad (2019).

2.3.3 - Periodic Review Policy (R, S) Inventory Model

Like the newsvendor model, the periodic review policy model also assumes probabilistic demand, but with an infinite planning horizon. According to Hadley & Whitin (1963), orders are placed on a set cycle of up to "S" units every "R" time period. Unlike the newsvendor model, this model does not just take one period into consideration. Instead, it assumes one can order on a set cycle regardless of how sales go in a period. This may work in some companies where stockout potential is low and there is more consistent demand, but the model would have to be continuously updated to account for changes in demand or prices. Periodic review policies have been utilized for remanufacturing (Fleischmann et al., 2003) and for perishable products (Minner & Transchel, 2010), among others. For a comprehensive review of this model, refer to Christou et al. (2020).

2.3.4 – Dynamic Lot Sizing

As introduced by Wagner & Whitin (1958), in dynamic lot sizing, or DLS, decisions are made over a finite planning horizon based on the frequency of sales versus the actual demand itself. During this specified period of time, demand is treated independently of each item and replenishment is done to meet the overall demand within this period "T". The objective of this model is to minimize the combined total holding costs and setup costs associated with all items needing replenishment, regardless of what those costs are individually. Some examples of where

dynamic lot sizing have been used are in biopharmaceutical manufacturing (Hahn & Sahlin, 2019) and in automated manufacturing systems (Akturk & Onen, 2002). For more information of the DLS, refer to the research of Silver, Pyke, & Peterson. (1998).

2.3.5 – Joint Replenishment Model (JRP)

The joint replenishment model is designed to minimize the joint holding and ordering costs based on a given demand. As introduced by Starr & Miller (1962) and further by Shu (1971), the joint replenishment is an aggregation model that is typically used when it makes sense to order a group of items simultaneously, rather than individually. One product is chosen as the "base" product, and every other product is compared to that product in terms of when to order.

For example, "Product 1" and "Product 2" would have different inventory levels that dictate when that product should be replenished. The time period for each replenishment is based on Product 1, and Product 2 is ordered whenever it is below the dictated inventory level indicated by the dotted line. With the ultimate benefit of using this model being the aggregation of replenishment orders, the joint replenishment model uses a total cost equation which takes into consideration one holding (Ch) and ordering (Co) cost for each replenishment cycle. These costs do not change regardless of the amount ordered and allow one to easily calculate how different products should be bundled together. Joint replenishment is used in industries such as retail grocery (Donovan, 2006) and fashion (Iannone et al., 2016), among others. For a comprehensive review of the joint replenishment problem, refer to the research of Khouja & Goyal (2008).

Each of these models focuses on two primary goals: minimizing cost and meeting service level.. The next section details why these models cannot simply be utilized for micro and small firms "as is". They need to be reviewed and adjusted to fit varying types of micro and small firms that need to manage inventory with a focus on increasing cash. As evidenced by the CCC, simply minimizing cost does not result in more cash availability. Since large firms are not as affected by periods of cash vulnerability due to their alternative access to finances and economies of scale, they are less sensitive to cash imbalances than micro and small firms. Therefore, many of these models are not applicable to be translated directly for micro and small firms. For these firms, a framework that focuses on "maximizing cash on-hand" is more relevant. These models instead

need to be reviewed and adjusted for our framework to fit varying types of businesses that need to manage inventory differently.

2.4 Inventory Management in Small Firms

While medium-to-large sized companies typically have a dedicated team managing inventory, alongside a system in place to do so, micro and small firms do not share the same benefit. These firms typically cannot afford to pay for an inventory management system nor do they have the capacity or knowledge to allow employees to dedicate their time in such a manner. With the given constraints, it is just as likely that the manager of a micro and small firm will be the one managing inventory themselves versus delegating that role to an employee.

While most inventory management systems were not established to address the key issue facing small firms – cash availability – those discussed in section 2.3 do fit into our designed inventory management framework and are thus the most applicable for our research. As these micro and small firms are very cash-centric and focus on running their daily operations, they have little long-term perspective or even data to support one of these other systems. They need a framework that requires little investment, is easy to understand, and has truly little need for technical expertise.

In the remainder of this capstone, we present a new inventory management framework that allows micro and small firms to focus on increasing cash availability. This segmented approach was developed after a 17-week data collection period incorporating six (6) firms in Bucaramanga, Colombia. After proving the viability of the framework, we also present a new business pulse dashboard that provides these firms a "one-stop-shop" to understand and manage their inventory quickly and easily.

2.5 Inventory Performance Metrics

To assess the inventory performance of small firms, we use the following metrics (Muller, 2003):

- **Inventory Turnover**: This is the number of times inventory is completely consumed and replaced within a specific time period, otherwise known as the number of inventory turns.

- **Average Stock**: This is the average amount of inventory maintained between two specific periods of time.
- **Days of Inventory**: This refers to the number of days that inventory will take to be consumed and replaced.

Details of how each of these metrics are calculated are found in Table 3.

Table 3: Metric Equations

Metric	Calculation
Inventory Turnover	Total Cost of Goods Sold / Average Inventory
Average Stock	(Inventory Cost at T1 + Inventory Cost at the T2)[1] / 2
Days of Inventory	365 Days / Inventory Turnover

[1] T1 represents the beginning of the period while T2 represents the end of the period.

3. FIELD STUDY: BUCARAMANGA, COLOMBIA

To gain a better understanding of how micro and small businesses in Latin America are run, we organized a field study with three micro and small firms in the city of Bucaramanga, Colombia.

3.1   Research Methodology

We conducted three (3) company tours in the following MSEs in order to gain insights into their daily operations:

1) **Dona Mireya** – Dona Mireya is a micro-sized candy shop with ~5 employees and a plethora of item options for customers. Each item has multiple flavors and is produced locally, and the business receives some government support.

2) **Eliecer Vasquez** – Eliecer Vasquez is a small-sized jewelry store with ~15 employees spread across two locations: the main storefront and the production facility. Caracas purchases the raw material and produces all of the jewelry themselves and is a relatively upscale small business.

3) **Banbury** – Banbury is a micro-sized bakery with ~10 employees that sells several special products with both small and large versions. Production is also fully manual and local, with simple designs that target the average consumer.

During the company tours, we collected information that is presented in the next section. These takeaways stemmed from a targeted set of questions we asked the business owners and employees, as shown in Table 4.

Table 4: Questions for Micro and Small Firm Owners | Excerpt

List of Questions	
How long have you been in business?	What are the products you sell the most?
What challenges do you face with suppliers?	Walk us through your processes. What typically drives disruption in those processes?
What are the largest risks you face every day?	Do you have a recurrent base of customers?
How is it working with your suppliers?	How hard is it to manage your cash?

3.2   Field Study Findings

While in Bucaramanga, we had the opportunity to both shadow micro and small firm owners as well as run a workshop for them. The shadowing consisted of meeting the individual business owners at their workplace, following them through their typical day-to-day work for about an hour, and then asking them targeted questions from the list in Table 3. The workshop itself was one that we developed while keeping in mind three goals: presenting to them about the importance of cash and the purpose of our research, identifying challenges that these business owners face, and working with the business owners to ideate solutions to these challenges. Thanks to these experiences, we were able to gain a better understanding of these firms.

Some of the key takeaways from this trip were:

1) **Micro and small businesses are indeed typically run on a "cash basis":** Owners of these businesses rely on cash to pay for shipments of new inventory, to react to unexpected changes in demand or need for money, and to pay off any accumulated debt.
    - Many of these businesses rely on government support in order to continue their daily operations, especially when they are struggling through trying times.
2) **Most "inventory management" is completed offline**: Business owners use their accumulated knowledge to make decisions and rarely use data-oriented decision making.
3) **Micro and small businesses share many of the same problems, regardless of industry:** Unlike large businesses which may differ in operations significantly across industries, micro and small firms tend to operate in a similar manner since tend to target the same

local population. Similarly, they all suffer from similar issues such as poor cash management and lack of funding opportunities.

4) **There is almost no leverage against suppliers**: Every one of the business owners we worked with explained that they typically have to accept the price that their supplier offers or move on to find another supplier; there is almost never any negotiation involved.

5) **Marketing and other types of business processes are typically either ignored or not taken advantage of**: Since there tend to be only a small number of employees in each of these businesses, many of these employees tend to be overworked and wear many hats. Many business improvement opportunities are missed due to lack of time or knowledge.

Gaining these insights not only allowed us to hear directly from micro and small business owners, but they also helped to validate the research we are doing and the impact it will have on these very individuals. By learning more about how these firms operate, we were able to confirm that access to cash was a shared issue prevalent in each firm, and that they all lack a systemized way to manage their inventory. This reinforced our knowledge on the importance of cash in the daily operations of these businesses, showed us how many of the same problems apply to every micro and small firm, and highlighted the accuracy of our motivation as many of these businesses were struggling to survive. These findings further helped set the stage for the quantitative research we then conduct to create the inventory framework and business pulse dashboard.

4. ANALYSIS & RESULTS

4.1 Data Collection

4.1.1 Data Collection Methodology

To create the most effective inventory management framework for micro and small businesses, we collected detailed information from several businesses regarding current inventory management processes. This information includes visibility on every product in the business, including sales and replenishment data, in order for us to best analyze the current inventory management process.

For this data collection period, we partnered with two universities located in the city of Bucaramanga (Universidad Autónoma de Bucaramanga & Universidad Pontificia Bolivariana) to leverage students at these schools to collect data from targeted micro and small firms in-person and on a weekly basis for 17 weeks. These firms come from varying industries, including restaurants, clothing stores, a barbershop, and an auto repair shop.

We used the Fulcrum App[2] to collect the following information from each business:

1) **Business Information**
   - This section is completed one time and includes basic business information such as the name of the owner, the number of employees, type of business, location, etc.

2) **Product Catalogue**
   - This section is completed one time and includes information about every product Stock Keeping Unit (SKU), such as the SKU description, a picture of the product, and product attributes. A SKU is a number associated with each specific product.

3) **Supplier Catalogue**
   - This section is completed one time and records every single supplier that the company utilizes as well as all products attributed to that supplier.

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[2] Fulcrum is an online application that is used for detailed survey analysis. For our research, it was our primary method of data collection.

4) **Customer Catalogue**

- This section is completed one time and records all customers (if applicable) that the business has a relationship with. This section is optional.

5) **Initial Inventory Record**

- This section is completed one time and records a "count" of the current inventory on-hand for every single SKU at the start of the data collection period.

6) **Sales Record**

- On a weekly basis, this section will record sales data for all SKUs.

7) **Inventory Arrival Record**

- On a weekly basis, this section will record inventory arrival data for all SKUs.

8) **Expenses Record**

- On a weekly basis, this section will record all additional expenses of the business.

9) **Final Inventory Record**

- This section is completed one time and records a "count" of the inventory on-hand for every single SKU at the end of the data collection period.

Figure 1 provides an example of what the Fulcrum app looks like from the user perspective.
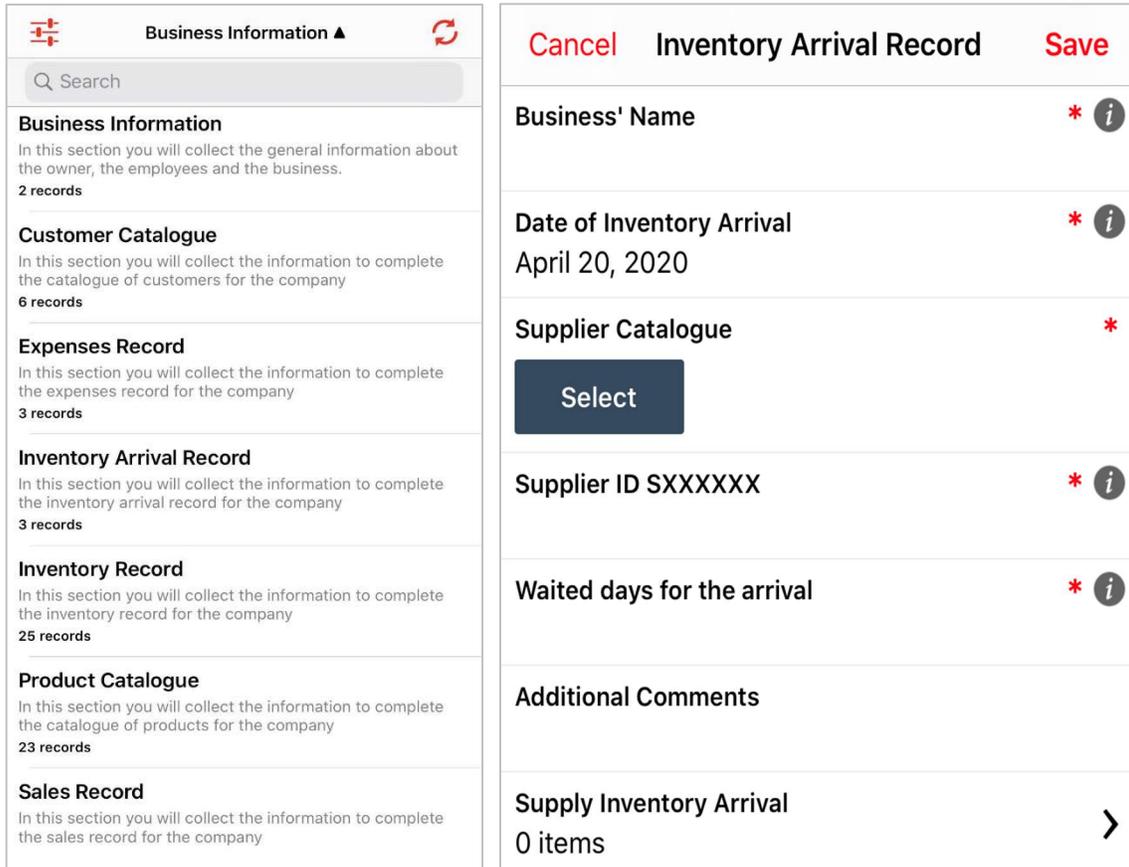
Figure 1: Example of the Fulcrum App Home Screen (Left) and Inventory Arrival Record (Right)

The students collected information from parts 1-5 at the very beginning of the data collection period, parts 6-8 throughout the data collection period on a weekly basis, and part 9 at the very end of the data collection period. This data was then inputted into Python Pandas[3] and thoroughly cleaned to ensure consistency and accuracy, before being analyzed and used in the development of our inventory management framework.

4.1.2 Inventory Framework Creation

The detailed information received during the data collection period is utilized to determine which inventory models best apply to micro and small businesses, that is, which models can be

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[3] Python Pandas is an online, open-source tool that utilizes the Python programming language for data analysis and visualization.

effectively used to help maximize cash on-hand. To do so, we analyzed the data and compared the applicability of current inventory models described in section 2.3. The development of the inventory framework had two phases: an initial pilot phase and an updated final phase. Following the data collection period, we utilized a combination of Excel and Python Pandas to clean and visualize the data.

After we completed the cleaning and visualization of the data, we developed the inventory management framework.. To finalize a viable inventory framework, we needed to create it in a usable format that all micro and small business owners would be able to access relatively easily. We present the results in section 4.2.

4.1.3   Problem Identification and Business Pilot

Throughout the data collection period, we ensured that we captured information we could use to view the struggles of these companies in a qualitative way. We compiled a list of questions for students to ask their business, which is outlined in Table 5. We then collected lists of the main problems that the students observed, which is elaborated on in section 4.2.5. The types of problems students looked for came verbatim from the MIT GeneSys Data Collection Guidelines, and include the following terms and definitions (Velázquez Martínez et al.):

- **Supplier Relationship Management:** This includes practices related to the process of working collaboratively with suppliers vital to the small firm's success and procurement needs.
- **Customer Relationship Management:** This includes practices related to the process of managing a company's relations and interactions´ with clients identifying their preferences, addressing their claims with the purpose of satisfying better their needs.
- **Operations Management:** This includes Practices related to all the operations and activities of the small firm includes the managing of the production of goods or services.

- **Planning & Business Processes:** This includes practices related to the planning process in the operating a supply chain and the business model in general.

Table 5: Problems Observed in Micro and Small Businesses

Type of Problem	Example of Questions
Supplier Relationship Management	What existing challenges do they face with their suppliers?
Customer Relationship Management	What channels do they serve? Are customers opportunistic or is there a solid customer base?
Operations Management	Does the business have the processes in place to operate and scale at will?
Planning & Business Processes	Does the business plan its finances and materials?

In collaboration with the students, we provided a set of specific recommendations for each business to improve their daily operations. These recommendations are based on the observations made throughout the data collection period. Following our review and approval, the students then presented to the businesses. A specific example of such recommendations is found in section 4.2.5.

After collecting all the data from our data collection process, we then analyzed that data in order to ascertain the performance of each participating business and develop ways in which to improve that performance, specifically focusing on the cash availability of each business.

4.2 MSEs Financial and Operational Analysis: Case Study in Colombia

4.2.1 Assessing Financial and Operational Performance in MSEs

To assess the performance of the micro and small firms we worked with, we analyzed two angles: financial and operational.

4.2.1.1 Financial Assessment

As shown in Figure 2, we analyzed the financial performance of the MSEs under a simplified income and cash flow statement with the aim to understand the main cash levers, drivers of spend, and the impact of working capital changes on cash gains and losses.

Income Statement | Simplified

Net sales	100
(-) Cost of goods sold	20
(=) Gross profit	**80**
(-) Selling expenses	50
(=) Operating profit	**30**
(-) Income tax expense[1]	10
(=) Net income	**20**

Cash Flow Statement | Simplified

Net income	20
(+) Δ Working capital	10
(=) Net cash from operating activities	**30**
(+) Cash from investing activities [2]	5
(+) Cash from financing activities [2]	5
(=) Net increase in cash	**40**

(1) This data was not collected
(2) Small firms generate little to none cash via investing or financing activities

Figure 2: Income and Cash Flow Simplified | Illustrative
(*This table was not considered for the analysis.)

The key components we analyzed are described in Table 6.

Table 6: Financial Components Analyzed for MSEs

Component	Description
Cost of Goods Sold (COGS)	COGS refers to the costs directly associated with the manufacturing or creation of the product sold.
Gross Profit	Gross profit refers to the total sales minus total expenses. This can increase by either raising the price or reducing the COGS. In the following sections we will also analyze the gross margin, which refers to the gross profit as a percentage of total sales.
Selling Expenses	Selling Expenses refers to the expenses associated with running the business (i.e. salaries, rent, transportation, etc.).
Net Income	Net income is the final earnings after covering the cost of goods sold, selling expenses, and income taxes. In this data collection, the taxes are not captured and therefore only the net margin will be analyzed. The net margin is the net income as a percentage of sales .
Change in Working Capital	For MSEs, the working capital directly refers to their inventory cost and is measured as the difference between the value of inventory prior to the data collection minus that value after the data collection. The MSEs studied did not have any other current assets or liabilities as they operate on a cash basis.

Within the income statement, we did not consider the depreciation and amortization expenses due to having no visibility of the micro and small firms' asset values and expected depreciation. In addition, we did not collect income tax expenses.

For the cash flow statement assessment, we focused the analysis on the cash generated from operating activities directly involving the production and delivery of products. None of the MSEs analyzed generated additional cash via investments (i.e. disposition of assets) and did not conduct financing activities (i.e. lending from banks or other lending institutions); thus, we did not consider these concepts for the assessment.

4.2.1.2 Operational Assessment

In operations, we analyzed the net sales in order to understand the demand behavior and identify the products generating higher returns on cash for the MSEs. We also conducted a different

approach to segment the demand considering the frequency of the demand per product versus the total sales generated. In this case, frequency of demand referred to the number of weeks that a product is sold during a specified time period. For example, in a data collection period of 15 weeks, having a frequency of 15 weeks meant that the product was sold every week..

As shown in Figure 3, we identified four (4) main segments. To determine high value products, the total sales per product had to be above the median of total sales. Similarly, the amount demanded had to be above the average frequency to be considered as a high frequency product. For example, the first quadrant: "High Value | Low Frequency" means that products within this quadrant generated above the median total sales but were sold less than five weeks during a data collection period of 10 weeks.
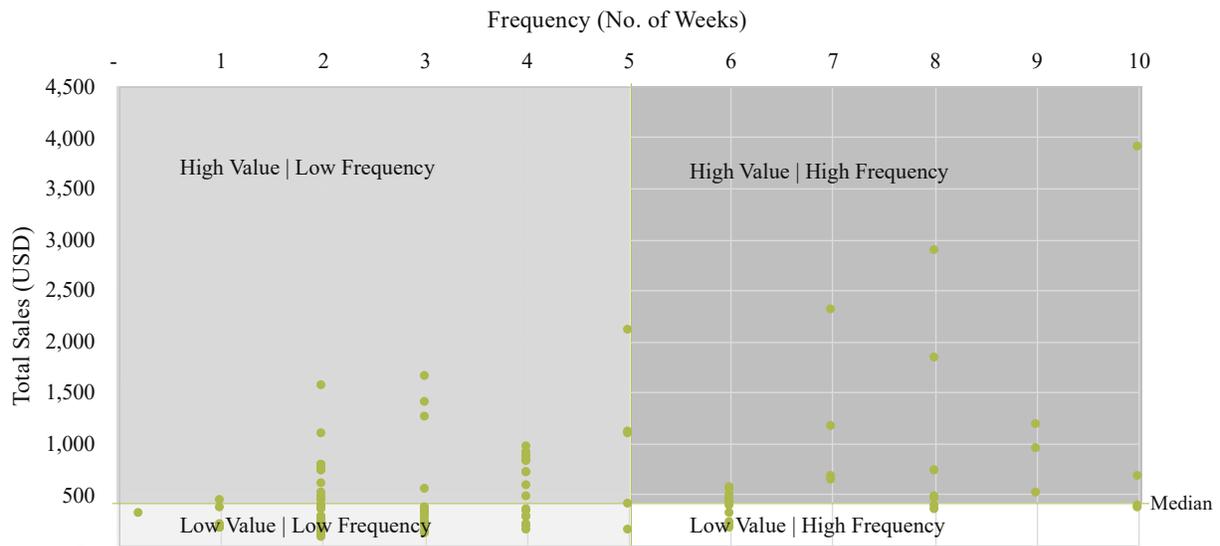
Figure 3: Total Sales vs Frequency | Illustrative

These segments per product were the main input in creating the inventory assessment and identifying cash opportunities for the MSEs. As shown in Figure 4, we analyzed each segment of products to estimate the average amount of cash invested. In addition, we calculated the inventory turns based on the total cost of goods sold in that segment along with the average inventory hold during the data collection period. We utilized these performance metrics for the inventory analysis as described in section 2.5.

High Value

Total Sales: $4,352 Average Stock: $1,415 **Inventory Turns: 0.2**	Total Sales: $5,135 Average Stock: $931 **Inventory Turns: 1.1**
Total Sales: $4,134 Average Stock: $1,315 **Inventory Turns: 0.9**	Total Sales: $1,035 Average Stock: $64 **Inventory Turns: 1.5**

Low Frequency ———————————————→ **High Frequency**

Low Value

Figure 4: Inventory Analysis per Segment | Illustrative

The demand and inventory analysis resulted in our proposed inventory management framework which is depicted in the results section, or section 4.2.3.

4.2.2 Case Studies for four MSEs in Colombia

The methodology used to assess the performance of MSEs was applied to four (4) firms in Bucaramanga, Colombia, within three (3) different industries: apparel retail, food service (restaurant), and auto repair retail. This analysis utilized data collected over 13-17 weeks.

The assessment of these four MSEs was conducted at the industry level as the two (2) companies within the apparel retail industry showed a similar cost structure and operation.

4.2.2.1 Financial Analysis

Cost of Goods Sold (COGS) and Gross Profit

The definitions for "cost of goods sold" and "gross profit" referred to in this section are those described in Table 6.

In Figure 5, the gross margins were compared across the different industries. The restaurant and apparel retail stores maintained a similar gross margin across their products while the auto repair retailer operated under lower margins. Gross margins in the apparel retail stores were the highest across industries and averaged 46%. The gross margins were not correlated to the quantity sold nor to the price or cost, but rather to the "uniqueness" of the products.

The restaurant margins averaged 43% and, similar to the apparel retail stores, the margin was independent to the quantity sold, price, or cost. It was driven mostly by the product category whereas complementary products like beverages showed the highest margin. The auto repair retailer showed the lowest gross margins across the industries, and it had a negative correlation between its margins and the cost of the product; higher cost products had a lower gross margin.
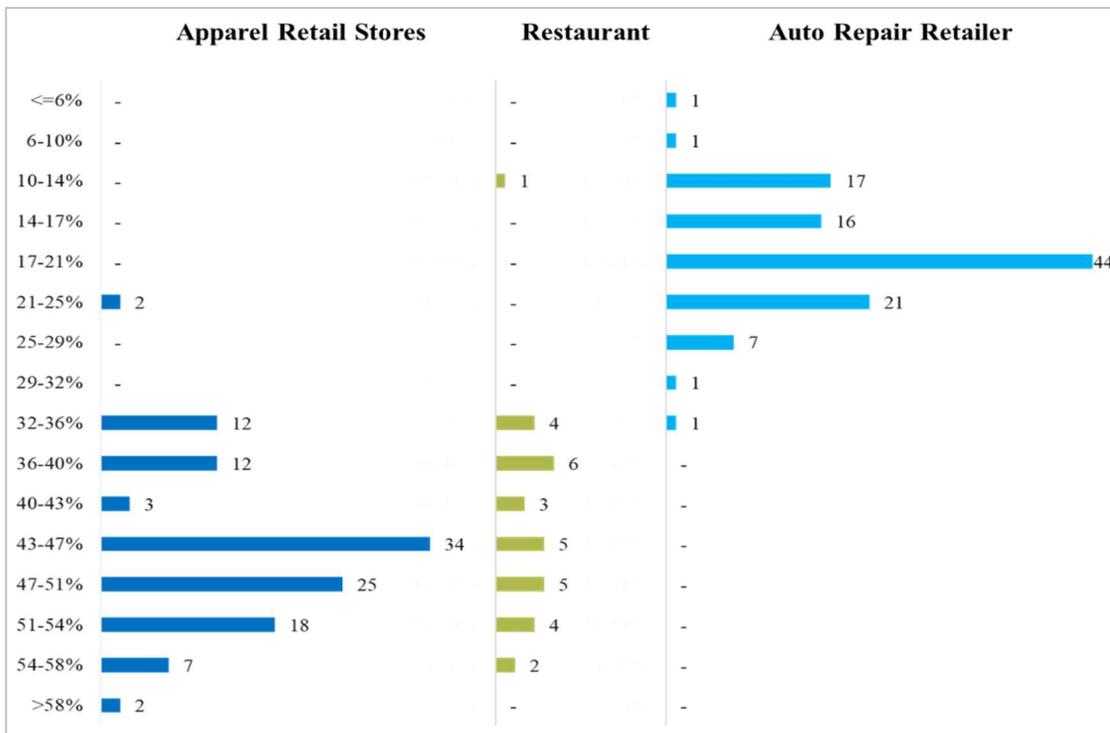
Figure 5: Number of Products per Gross Margin

As shown in Table 7, the MSEs did not establish a pricing differentiation between segments, resulting in similar gross margins per segment. One of the strategies large firms follow is the differentiation of pricing depending on the product segment. For example, having half of the current gross margin in the low value / low frequency products can help to have a lower price for those products, resulting in increased sales. This kind of strategy can be tested in micro and small firms to ensure higher frequency of demand and a higher return of cash. Both the restaurant and the auto repair retailer showed the lowest margins in the high value and low frequency products, which suggested that these firms instead generate high total sales by selling at a higher volume and exploiting the economies of scale prevalent with lower value products.

One initial approach for these MSEs can be to have a lower gross margin in the low frequency / low value products to test if that can increase the frequency of the demand. If that is not the case, the small firm should reconsider having these products in their portfolio as the cash invested in these products can be re-invested in other segments.

Table 7: Gross Margin per Product Segment

Type of Micro and Small Firm

Segment	Apparel Retail Stores	Restaurant	Auto Repair Retailer
High Value - High Frequency	48%	46%	19%
High Value - Low Frequency	48%	37%	14%
Low Value - High Frequency	-	44%	23%
Low Value - Low Frequency	45%	44%	20%

Selling, General, and Administrative Expenses

As shown in Figure 6, rent and salary costs were the highest expense categories across industries. We also analyzed the fixed expenses, which were recurring expenses per time period (i.e. rent) and are independent of sales, along with the variable expenses, those which were highly associated with sales (i.e. employee sales bonuses).

For these types of expenses, we found the following:

- The **apparel retail stores** showed high impact driven by their fixed expenses, representing 82% of total sales during the data collection period, with rent being the highest expense. Variable expenses represented 57% of total sales, higher than the gross margins generated.

- For the **restaurant**, fixed expenses represented 15% of total sales, mainly driven by rent, while variable expenses were 13% of total sales, driven by salaries. During the data collection period, the restaurant had a positive net income with total expenses accounting for approximately ~60% of the gross margin.

- The **auto repair retailer** did not cover rent, which lowered the total fixed expenses to 4% as a percentage of total sales. However, variable expenses, mainly driven by salaries, accounted for 20% of total sales which was higher than the profit margin.
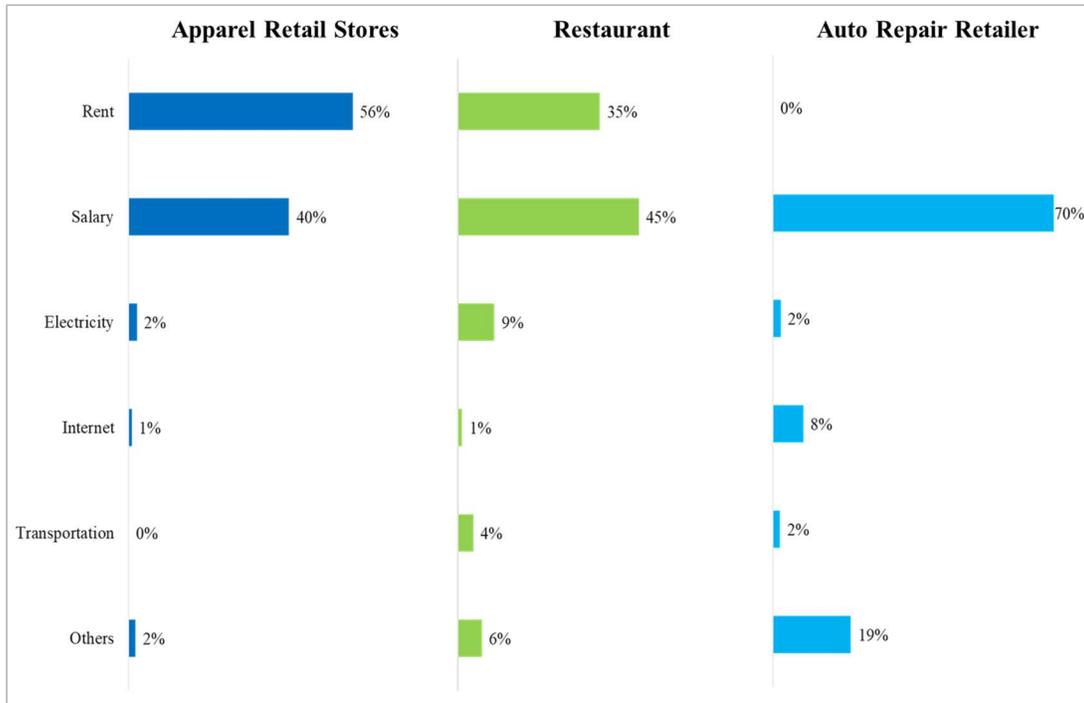
Figure 6: Total Expenses as a Percentage per Category

Net Income

To summarize the performance of the three industries studied, we evaluated the cost of goods sold and selling, general, and administrative expenses as a percentage of total sales. As shown in Table 8, the restaurant was the only industry with positive net income. The auto repair retailer and the apparel retail stores had a higher base of selling expenses that surpassed the gross profit.

Table 8: Net Income Per Industry

	Apparel Retail	**Restaurant**	**Auto Repair Retailer**
Total Sales	**100**	**100**	**100**
(-) COGS	53	56	82
= Gross Profit	**47**	**44**	**18**
(-) SG&A	139	28	24
= Net Income	**(92)**	**16**	**(6)**

Net Cash from Operating Activities

As described in Figure 2, the cash balance generated by operations is calculated by the net income plus the change in working capital. The change in working capital was positive if the inventory cost at the end of the data collection period was lower than the inventory at the start of the project.

The cash balance was analyzed over the total sales basis, as seen in Table 9.

Table 9: Cash Balance per Industry

	Apparel Retail Store	**Restaurant**	**Auto Repair Retailer**
Total Sales	**(92)**	**16**	**(6)**
(+) Change in WC	28	NA*	21
(=) Cash at the end of the period	**(63)**	**16**	**15**

(*Inconsistencies were identified in the inventory data collection)

For our net cash analysis, we found the following:

- The **apparel retail stores** reduced the total inventory during the data collection, adding cash to the companies; however, the cash at the end of the period remained negative. These stores would need to focus on reducing expenses to later unleash the benefits of reducing inventory.
- The **auto repair retailer** ended with 15% of total sales as available cash by reducing its inventory balance by ~50% during the data collection period. The percentage of cash invested in inventory must be further reduced to positively increase the final cash balance.

4.2.2.2 Operational Analysis

Demand Analysis

We utilized the total sales as the demand signal and the main input for the demand analysis. The portfolio size in the apparel retail stores was 300 SKUs, but only 115 recorded sales during the data collection period; the auto repair retailer comprised 109 SKUs while the restaurant offered only 30 SKUs.

Our demand analysis resulted in the following findings, evidenced in Figure 7:

- The **apparel retail stores** had a more complex portfolio with 65% of their products demanded for one week only. This represented a challenge for the business as they needed to maintain a diversified inventory to offer different sizes, colors, and seasonal items.

- The **restaurant** presented an opposite behavior with 70% of the products demanded almost every week. The products with lower frequencies than 12 weeks were offered to the consumer only for specific events and seasons.

- In the case of the **auto repair retailer**, 50% of its products were demanded every three (3) weeks while only four (4) were demanded weekly. Understanding the frequency of demand of the portfolio and the number of items within each frequency were key to defining the segmentation proposed.
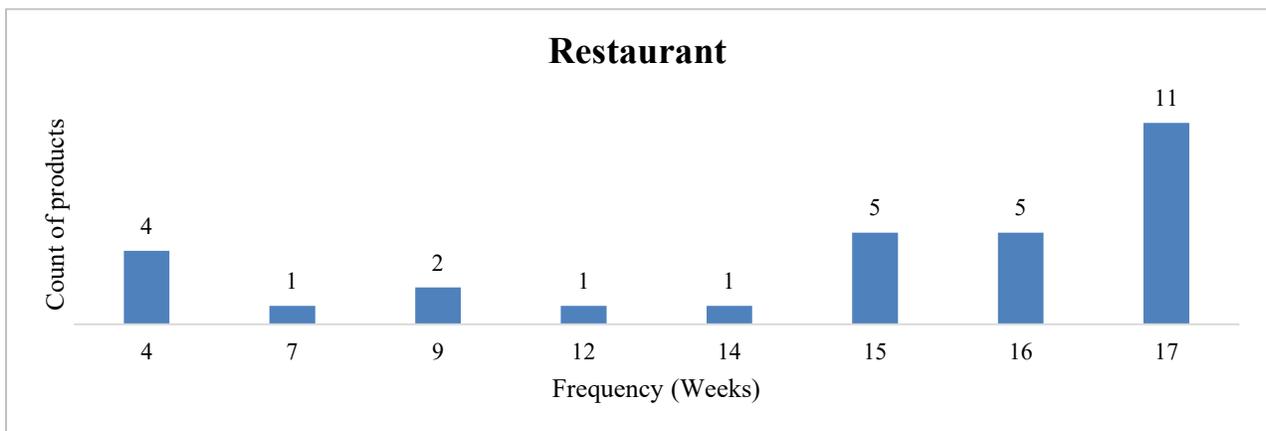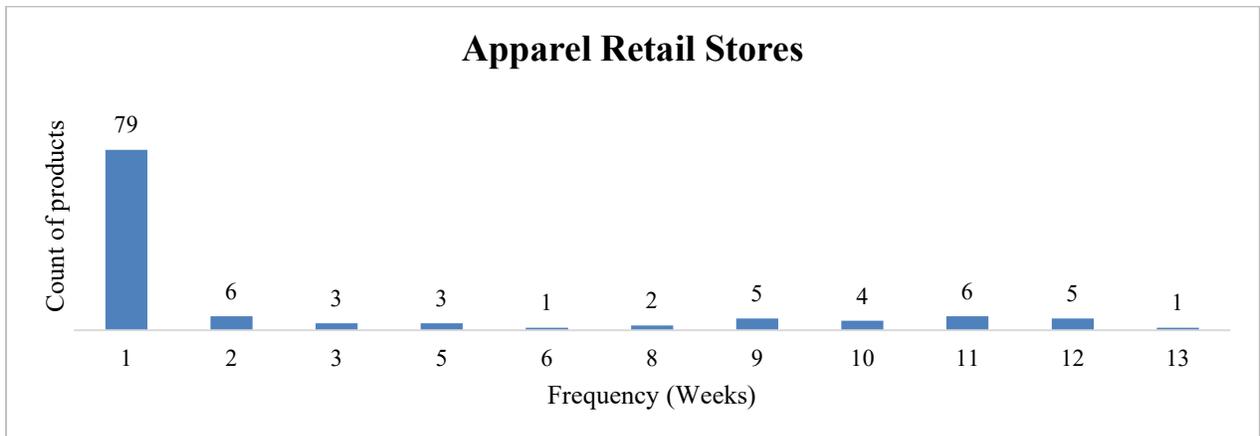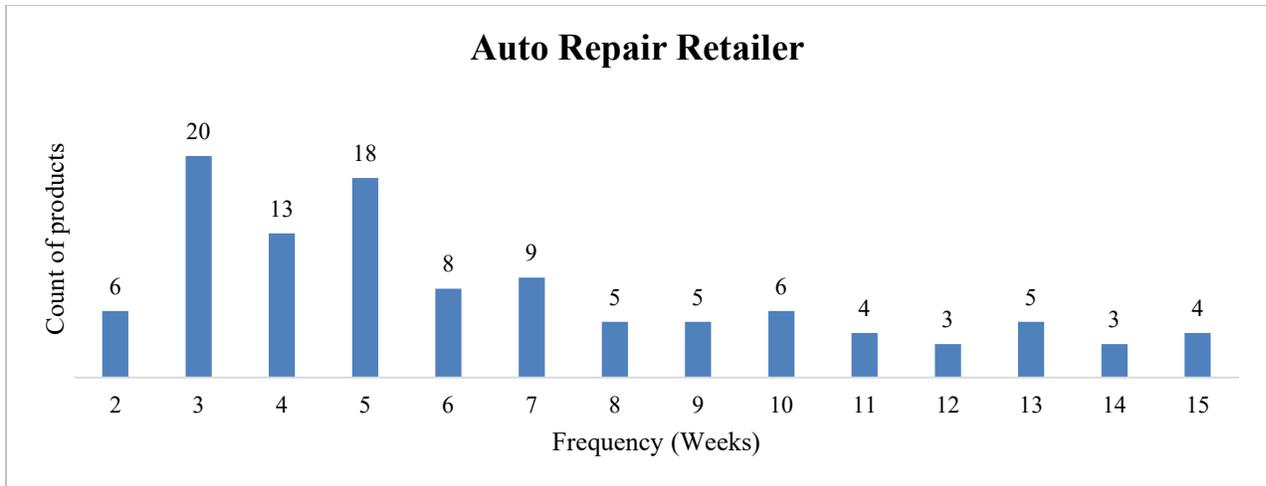
Figure 7: Frequency of Demand and Number of Products

Total sales generated by the products was another factor considered for the segmentation, and this value described what the total return to the business was during the data collection period. As shown in Figure 8 and based on the analysis of the gross margin, there was little differentiation if the segmentation was based on total sales versus total profit. The importance of understanding the demand frequency versus the total sales was to ensure the availability of the items frequently demanded, independently of the season, and thus increase the conversion of inventory into cash.

Our analysis of the frequency of demand vs total sales and profits were as follows:

- For the **apparel retail stores** studied, most of the totals sales were generated by the products demanded at least every two (2) weeks.
- In the case of the **restaurant**, the seasonal item sales and profits were higher than some of the items that were frequently demanded. Having the right inventory for both moments of demand ensured the business owner a higher return on cash, regardless of the time of year.
- Finally, for the **auto repair retailer**, the most frequently demanded products and those demanded every three (3) weeks or less generated the majority of total sales. One of the main differences for the auto repair retailer was that the items sold with greater frequency had lower prices and the items demanded less had higher prices.
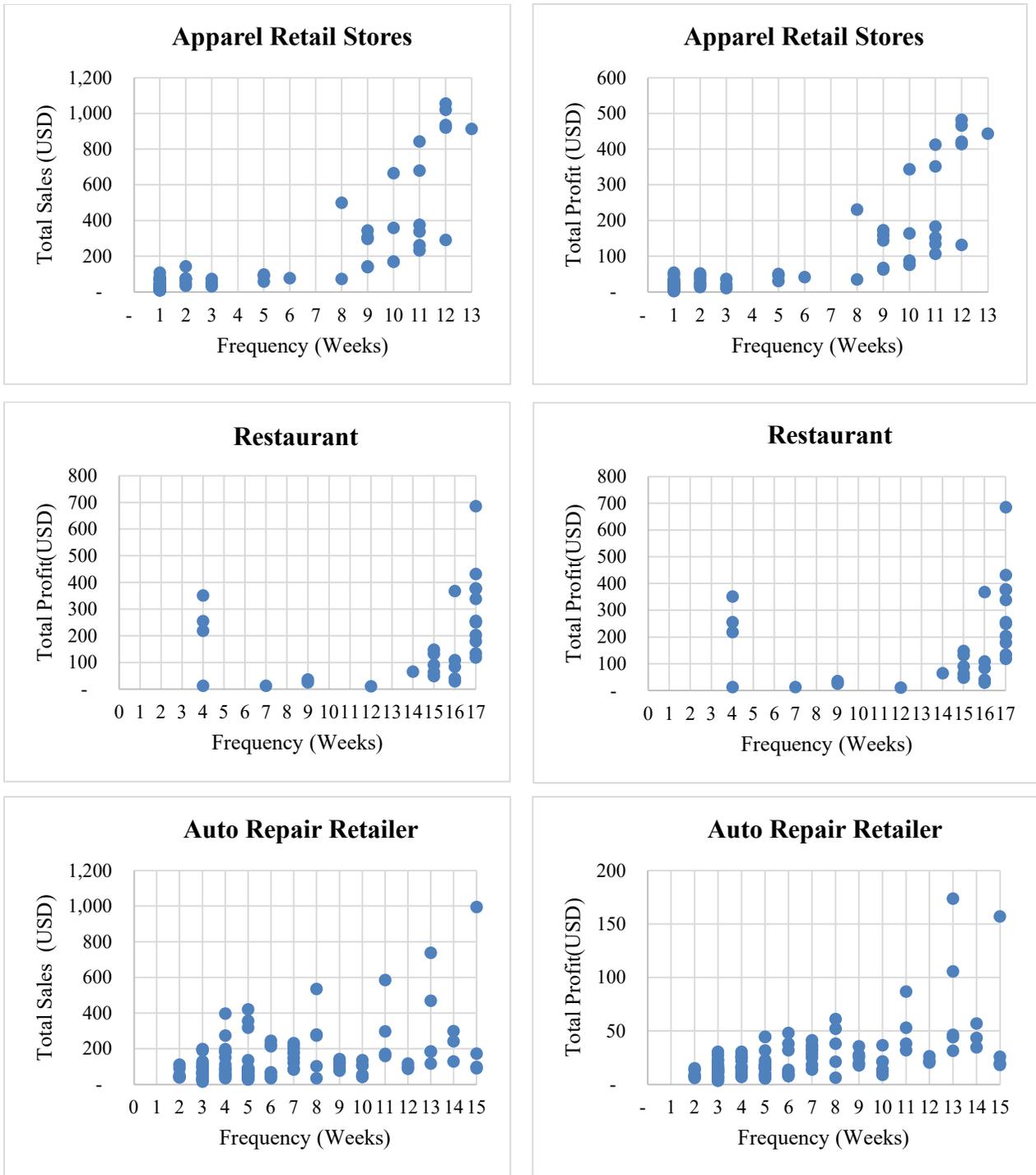
Figure 8: Frequency vs Total Sales and Profit per Industry

For each of the industries, the thresholds determined were as follows:

Industry	Frequency Threshold (Weeks)	Total Sales Threshold ($ USD)
Apparel retail	>= 7	33
Restaurant	>= 9	$281
Auto repair	>=8	$100

As a result, the segmentation per industry is illustrated in Table 10. These segments established the outline for us to analyze their inventory and propose our inventory management framework.

Table 10: Product Segmentation by Industry

Apparel Retail Stores: Segment	Products	Sales (USD)	Gross Profit (USD)
High Value - High Frequency	23	11,023	5,238
High Value - Low Frequency	31	1,853	896
Low Value - High Frequency	-	-	-
Low Value - Low Frequency	61	990	445

Restaurant: Segment	Products	Sales (USD)	Gross Profit (USD)
High Value - High Frequency	12	8,096	3,719
High Value - Low Frequency	3	2,241	825
Low Value - High Frequency	13	2,003	880
Low Value - Low Frequency	2	56	25

Auto Repair Retailer: Segment	Products	Sales (USD)	Gross Profit (USD)
High Value - High Frequency	28	7,118	1,364
High Value - Low Frequency	29	5,890	832
Low Value - High Frequency	7	439	99
Low Value - Low Frequency	45	2,713	542

Inventory Analysis

We analyzed the inventory by segment to better understand the amount of cash invested and the inventory turns as shown in Figure 9. Our findings were as follows:

- The **apparel retail stores** had a total inventory turn of 0.8, maintaining 466 days of inventory or equivalent to 13,200 USD of cash. Most of the inventory of the business was invested in high value / high frequency products, which present the highest opportunity of reduction for the business as this segment had a stable and predictable behavior. The seasonal items presented the highest turns and lowest average inventory.

- The **auto repair retailer** had an average inventory of $5,730 and 1.5 turns which resulted in ~243 days of inventory. The biggest opportunity for this firm was in its low frequency products which also presented the highest level of inventory in comparison with its sales.

Apparel Retail Stores

Total Sales: $1,853
Average Stock: $395
Inventory Turns: 1.9

Total Sales: $11,023
Average Stock: $10,553
Inventory Turns: 0.9

Total Sales: $990
Average Stock: $2,335
Inventory Turns: 0.2

High Value

Low Frequency

Low Value
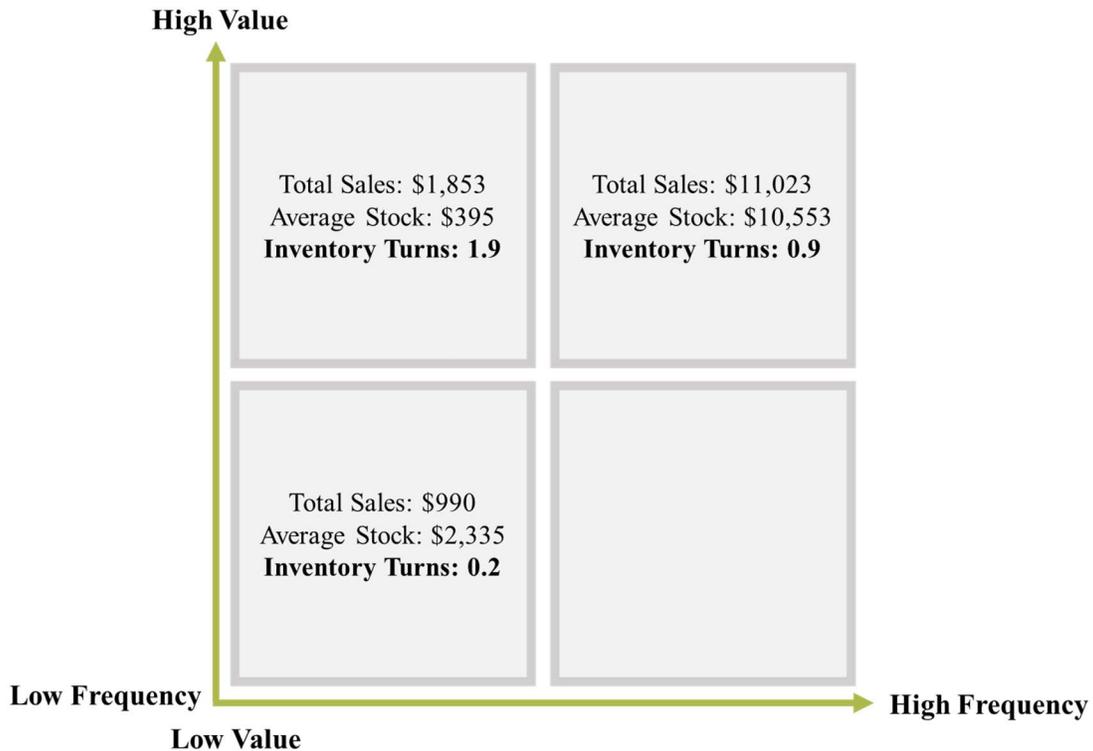
High Frequency

Auto Repair Retailer

Figure 9: Inventory per Segment and Industry

Based on the inventory analysis per segment, we suggested the following:

- **High Frequency | High Value :** The demand in this quadrant was stable, predictable, and with a normal distribution as shown in Figure 10. This is illustrative of the behavior of the product with the highest cycle inventory (~7,500 USD) in the apparel retail store, as well as a high selling product in the auto repair retailer.

  The product from the apparel retail stores had an average sale of four (4) units per week and a standard deviation of three (3), and the product in the auto repair retailer had an average of 1.6 in sales with a standard deviation of 0.7.
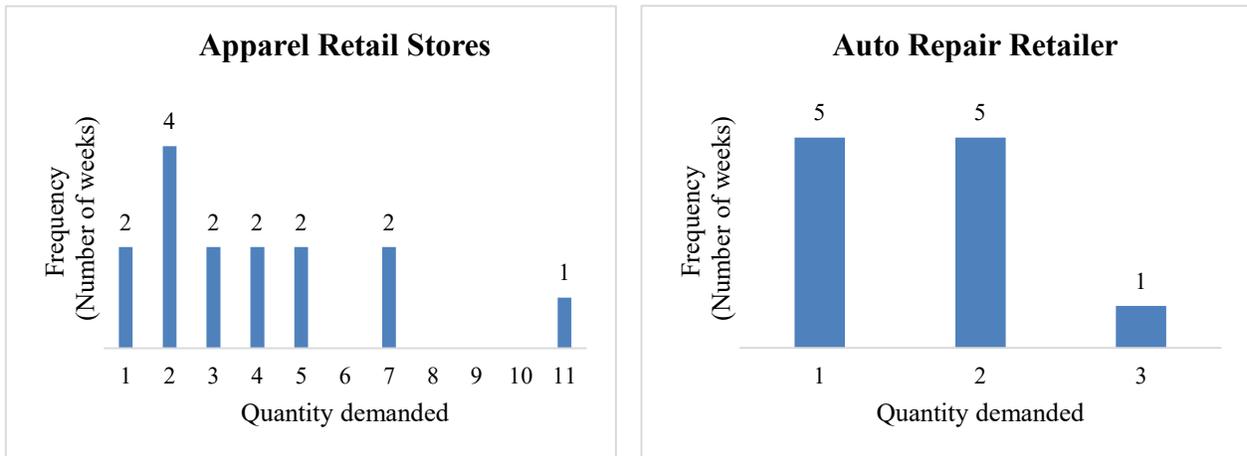
Figure 10: Quantity Demanded and Frequency in High Frequency | High Value

For this segment, we proposed a continuous review to ensure high availability and trigger replenishment as soon as it is needed. This model resulted in a reduction of 80% in the inventory of products analyzed in the apparel retail stores and suggested a cycle stock of 16 units valued at $1,600 with a monthly replenishment. The same model was applied in the auto repair retailer product, which yielded a reduction of 40% of inventory held during the same time period.

- **High Frequency | Low Value:** For this segment, the amount invested in inventory was recommended to be capped. As joint replenishment or dynamic lot sizing model can maintain an optimal inventory level with a known and stable demand, as shown in this segment. Specifically, the joint replenishment model helps couple the replenishment across different products located in this segment. We argue that, in addition to these two models, this segment requires further development and we suggest making it more robust by including the function of cash maximization instead of cost reduction.

The auto repair retailer had a cycle stock of $93 USD which can be reduced to $53 by maintaining a maximum and minimum approach; a reduction of 43% of the total cost currently invested in this segment.

- **Low Frequency | High Value:** The items in this segment were highly seasonal but drove a high revenue to the business. Carrying a seasonal item inventory generated a tradeoff between falling into a stockout while also having an excess of inventory with lower value after the season. These characteristics were appropriate to apply a newsvendor model.

  In the apparel retail stores, the amount invested in this segment was low but still with estimated benefits. With a salvage value of 50% of the cost, there was an estimated reduction of 5% in the current cycle stock. The auto repair retailer maintained a cycle stock of $2,634. If the business were to apply a newsvendor model for this segment, a reduction of 70% in inventory could be achieved with a salvage value of 10% of the current cost.

- **Low Frequency | Low Value:** The demand on this segment was infrequent and the products were not driving revenue to the MSEs, thus having a periodic review approach with a capped investment and setting a minimum threshold to replenish will reduce complexity and cash invested.

  In the apparel retail stores, the periodic review showed estimated benefits of 80% inventory reduction with a monthly review and targets that secured 95% coverage of the variability. In the case of the auto repair retailer, the model resulted in estimated benefits of 43% reduction of the current cycle stock.

The analysis of these inventory models combined with our demand analysis has led us to suggest this new inventory management framework based on the frequency of the demand and the total sales generated to the firm, as described in section 4.2.3.

4.2.3 Results

Based on the case studies conducted in Colombia, the proposed inventory management framework in Figure 11 generates inventory cost savings within the range of ~50-80% to MSEs by reducing days of inventory per segment. To segment each product, we consider the frequency of the demand (the number of weeks a product is sold within a specific time period) as well as the sales generated to the business. To determine the different quadrants, we utilize the average demand frequency to

differentiate between high frequency and low frequency products, as well as the total sales per product compared to the median sales to divide between high value and low value products.

In addition, providing visibility to the MSEs on their financial performance is key to ensuring that cash is managed across the company. One of these benefits is described in section 4.2.2.1, where we suggest having a different pricing strategy depending on the product segment. For example, we argue that having a lower gross margin in the low frequency / low value products can help the firm instead capitalize on economies of scale to increase sales of those items.
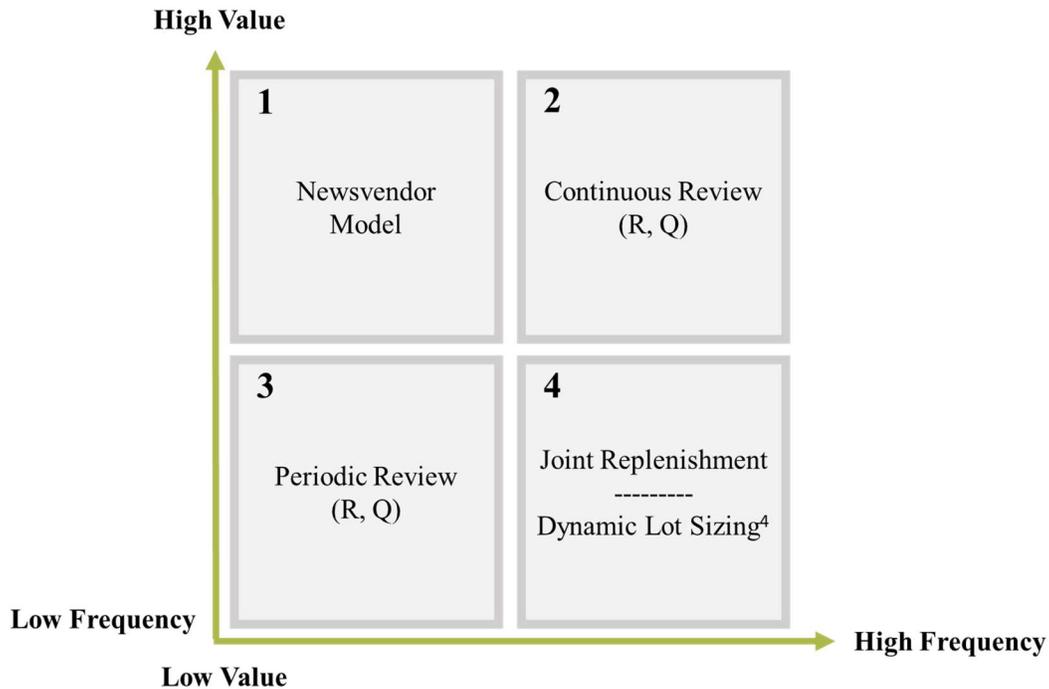
Figure 11: Inventory Model Framework for MSEs

Moreover, as shown in Figure 12, we suggest for micro and small firms to have a differentiated inventory management approach depending on the product segment. Having a clear understanding of the demand behavior of each product helps to make consistent inventory decisions in different time periods. Our case studies in Colombia show evidence that micro and small firms are investing cash in the wrong product segment; for example, they tend to have more inventory in the low frequency / low value segment instead of in high frequency / low value. Changing the way these firms think about their products in a simplified framework enables them to realize the benefits and power of inventory management.

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[4] This quadrant could potentially host other models besides Joint Replenishment and Dynamic Lot Sizing.
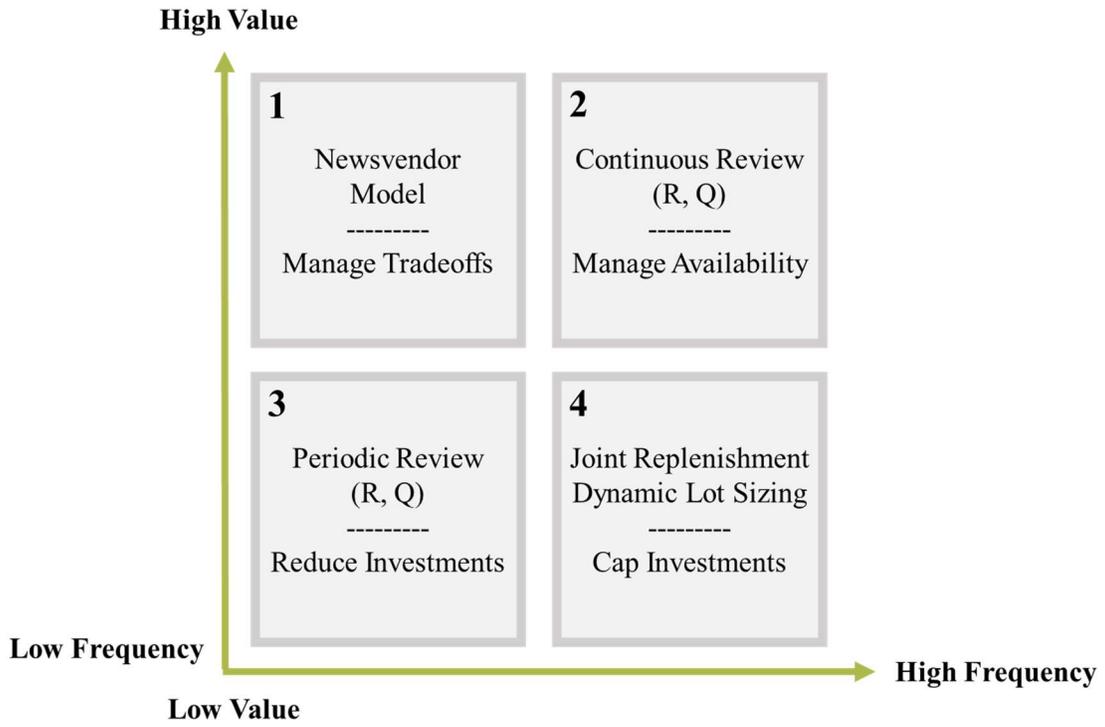
Figure 12: Inventory Strategy by Segment for MSEs

Explanations for Figure 12 can be found in Table 11.

Table 11: Inventory Management Framework – Breakdown

| Segment	Model	Strategy	Actions
1	Newsvendor Model	Manage Tradeoffs	The products in this segment are typically seasonal and thus micro and small firms need to balance the risk of having too much inventory. To do so, they would need to reduce product value after the season or eat the opportunity cost of not having enough to cover the season. These products normally represent high value and we suggest gross margins to be higher.
2	Continuous Review	Manage Availability	Secure availability of these products as they will generate a higher return of cash. In the case a micro or small firm has limited cash during a period of time, this is the segment where investments need to be made. Another potential opportunity is to start managing longer days of payment to the supplier to decrease the cash conversion cycle.
3	Periodic Review	Reduce Investments	The items in this segment need to be evaluated carefully to decide if they should remain in the portfolio or not. Micro and small firms should avoid having more cash invested in this segment than the others. A possibility here is to reduce the gross margins to see if the products can move to a higher frequency.
4	Joint Replenishment, Dynamic Lot Sizing, or Other	Cap Investments	These products ensure fast return of cash but do not generate high value to the company. Micro and small firms need to ensure availability but also need to focus on having the optimal cash invested in this segment, As mentioned before, there is opportunity to develop an additional inventory model that focuses on maximizing cash instead of cost here.

Based on the inventory framework in Figure 11, we ran inventory simulations with the inventory models included per segment and compared our results against the actual inventory replenishment observed during the data collection period. Based on these simulations, we suggest the following:

Apparel Retail Stores

As shown in Figure 13, savings in inventory can be achieved by segment compared to the replenishment made during the data collection period. This figure also presents the current average inventory and expected saving, as a percentage, along with the equivalent savings value in inventory. For example, if the micro or small firm utilizes the continuous review policy for the high value / high frequency products, it can potentially see an 80% reduction of current inventory.

In total, the inventory simulation resulted in having increased inventory turns up to 2.5 – three times more than the current state. This represents ~$10k USD savings in total, which represents ~66% of its total sales.

Apparel Retail Stores

	High Value	
1		**2**
-5%		**-80%**
Average Stock: $395		Average Stock: $10,553
Savings: $20		Savings: $8,442
3		**4**
-80%		
Average Stock: $2,335		
Savings: $1,875		
Low Frequency		High Frequency
	Low Value	
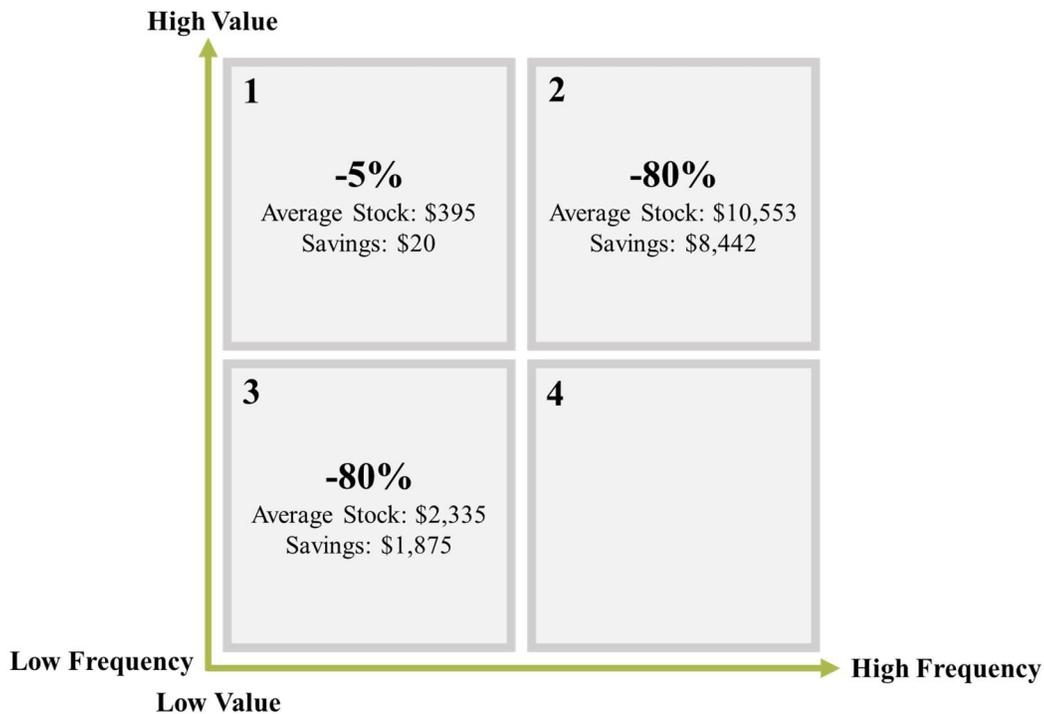
Figure 13: Estimated Inventory Savings by New Framework – Apparel Retail Stores

Auto Repair Retailer

In Figure 14, we present the results of the inventory simulation by segment for the auto repair retailer. If the auto repair retailer follows the recommended framework, it can reduce its inventory by ~$3k USD and increase its inventory turns to six (6), maintaining only 66 days of cash invested in inventory. This improvement translates to the micro or small firm recovering 60% of its current sales and having those savings in the form of cash.

Auto Repair Retailer

	High Value	
1		**2**
-70%		**-40%**
Average Stock: $2,634		Average Stock: $1,451
Savings: $1,843		Savings: $580
3		**4**
-55%		**-43%**
Average Stock: $1,552		Average Stock: $93
Savings: $853		Savings: $40

Low Frequency — High Frequency
Low Value
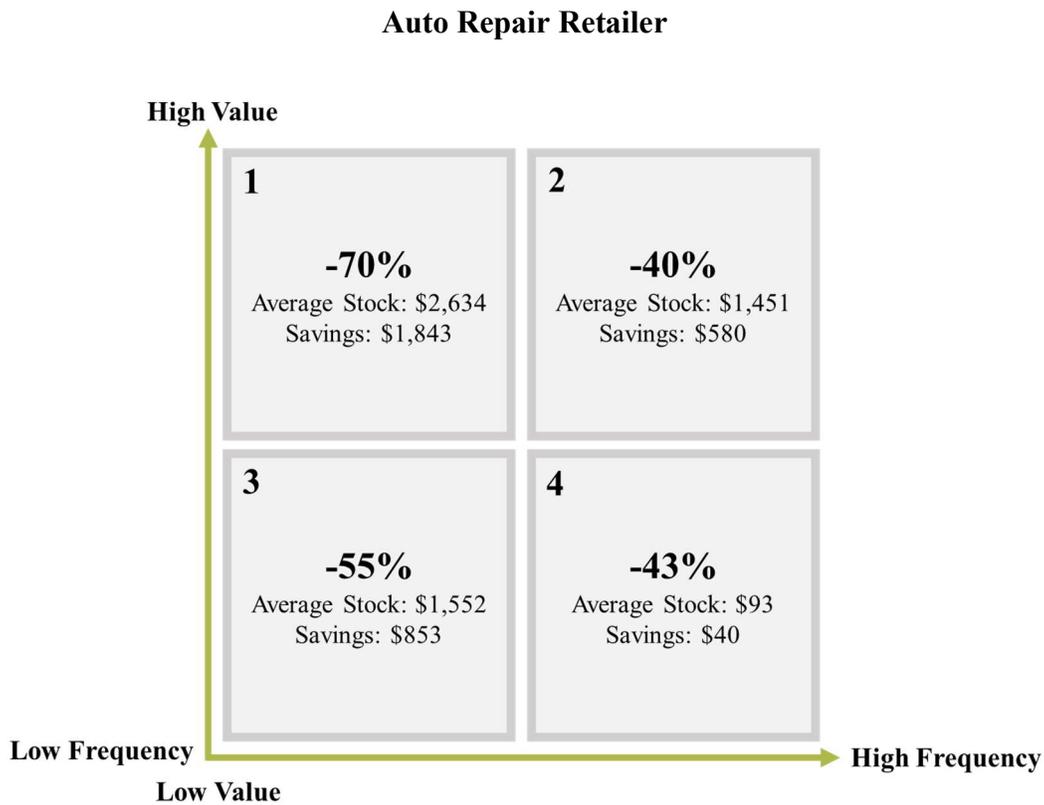
Figure 14: Estimated Inventory Savings by New Framework – Auto Repair Retailer

We have shown evidence that micro and small firms are different in comparison to large firms as their cash conversion cycle heavily depends on the days of inventory they hold. As depicted in Table 12, we show how large firms pay their suppliers until they collect the cash from their customers and sell their inventory, resulting in a negative cash conversion cycle. The large firms referenced here are the same as in Table 2 (Amazon, Walmart, and Costco). This is something that micro and small firms do not have the luxury to do, as they typically do not manage payment terms longer than one day.

Table 12: CCC Comparison of Large Firms vs Micro and Small Firms

Firm	DIO	(+) DSO	(-) DPO	(=) CCC
Three Largest Retailers Worldwide	38	11	54	-5
Apparel Retail Store	456	0	0	456
Auto Repair Retailer	243	0	0	243

4.2.4 Weekly Pulse Dashboard

In conjunction with the inventory management framework we created, we also utilized the data visualization software "Power BI" to create a dashboard for each of the small businesses we partnered with. The dashboard itself has been created in Spanish for our business partners. This dashboard consumes the data captured in the Fulcrum App and utilizes an ETL code in Python to enable the different views and allows the businesses to have a weekly vision of how they are performing:

Start View: As seen in Figure 15, the initial screen allows the business owner to select a topic of interest such as sales (Ventas), gross profit (Ganancias), expenses by type (Gastos), initial inventory count and replenishment (Inventario), and a cash balance of its business (Balance).
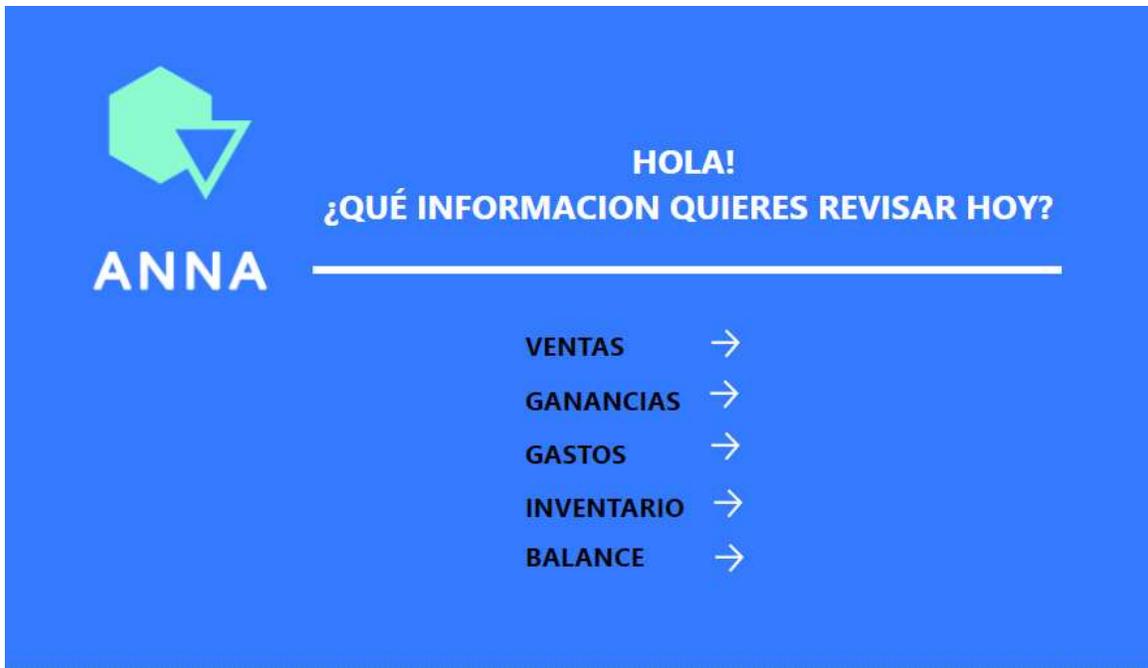
Figure 15: ANNA Weekly Pulse Dashboard – Start

Each of the topics consist of a detailed view that can be seen in Appendixes A – E.

In addition to the inventory management framework we propose as well as the weekly pulse dashboard we are introducing, we also have more qualitative insights to present.

4.2.5 Qualitative Insights

Throughout the data collection period, the students worked with the micro and small firm owners to identify the key challenges these owners are facing in daily operations. The students then identified potential root causes for those challenges and proposed potential recommendations for improvement. An excerpt of these "key insights" tables is shown in Table 13.

Table 13: Top Challenges Observed by Students

Process	Challenge	Potential Root Cause	Solution
Supplier Relationship Management	Owner is completely ignoring of how to manage suppliers	- This is not the owner's focus - Overconfidence in the outsourcing process	Start to learn the basic process to make some clothes in-house
Customer Relationship Management	There are no changing facilities and for that reason people ask for clothes and then return them	- Social media is easier to do for marketing - Costs would be increased - Taxes are added with new facilities - Not enough profits to sustain	Establish a place where the people can go to fit the T-shirts on or view them (i.e. an apartment)
Operations Management	T-Shirts necks are not suitable to customers	- Wrong measurements - Outsourcing with no quality control - Equipment in bad condition	Focus on a few products and emphasize quality
Planning & Business Processes	Excessive inventory	- Inappropriate market study - Less sales - Deficient marketing - Big order quantity	Reduce the quantity on the next order

4.2.6 Inventory Management App: ANNA[5]

In conjunction with the introduction of the inventory management framework itself, we developed a prototype of an application that could be utilized by micro and small firm owners. This app is called "ANNA", just like our dashboard. The naming convention is similar to Amazon's "Alexa" or Apple's "Siri" in that the name is short, fun, and easy to refer to. Additionally, considering that we want this application to be utilized by micro and small businesses in North America as well as Latin America, we wanted the name to be friendly to both cultures.

The application itself follows the same format as the weekly pulse dashboard introduced in section 4.2.4. Micro and small firm owners can navigate through the app in order to gain weekly visibility into their daily operations, such as the amount of cash they have invested in inventory, all easily accessible at their fingertips. The home screen currently provided in the app is seen in Figure 15, with subsequent screens following the same format as the dashboard.

[5] In addition to the definition for "ANNA" above, it is also a combination of our names – Analiz and Nathan (Trevor's middle name).

Figure 16: "ANNA" Inventory Management App Home Screen

5. CONCLUSIONS

Micro and small firms (MSEs) struggle to survive and rely on cash to run daily operations. These firms are prevalent in Latin America and contribute greatly to the overall economy and employment. This project had the objective of increasing the cash availability for such businesses via better inventory management. Our research specifically analyzed the connection between inventory management and cash availability, highlighting the positive relationship between improved inventory management and increased cash on-hand. This is particularly important in the context of MSEs due to the high risk of business failure and the fact that these firms operate on a cash basis. We approached this project through two phases: conducting a field study analysis in Bucaramanga, Colombia, and mapping the financial and operational performance of six (6) such firms. The field study was conducted in the form of shadowing micro and small business owners as well as organizing and presenting a workshop, where we observed the critical need for better cash availability in these firms.

To map the financial and operational performance of the six firms we partnered with, we developed an inventory management framework that provides targeted inventory model recommendations for different segments of products and demand patterns. We did this by gathering detailed information from these firms over ~17 weeks that included visibility to all their products, finances, and inventory decisions. By utilizing this framework, these firms saw a reduction in average inventory and an overall increase of inventory savings up to ~80%, in addition to increased inventory turns per segment. Finally, we introduced an inventory dashboard that allows these owners to have weekly visibility as to when and where their cash is being spent. With this increased transparency combined with the new inventory management framework, micro and small businesses should be in a better position for business success.

5.1 Further Research

To further researchers, we recommend identifying and investigating other opportunities in helping micro and small firms maximize their cash availability. While our research shows evidence that an improved inventory management framework can indeed lead to better cash management, these firms still face many challenges in knowing when and where to use that cash. There is still a gap in segment 4 of our framework that aims at high value / high frequency products. We recommend the development of a mathematical model targeting this segment for a future research avenue.

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APPENDIX

Exhibit A – Business Pulse Dashboard: "Sales"
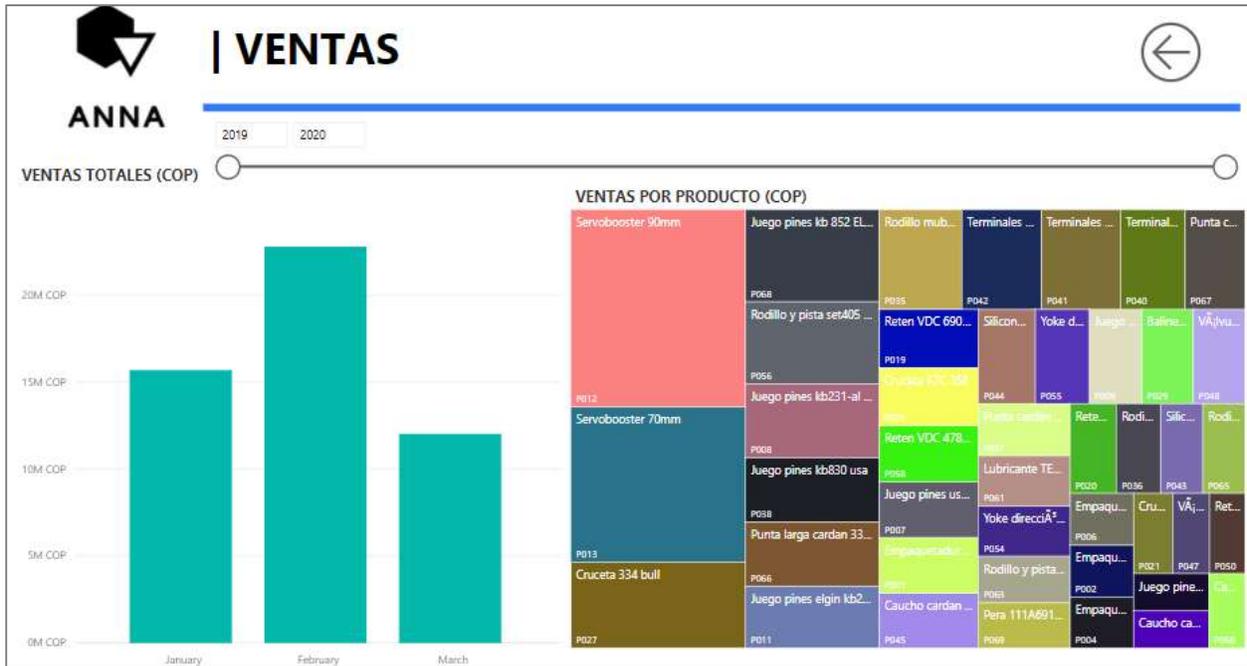
Sales (Ventas): The first view that micro and small firm owners will see is their overall sales. The left-hand side shows overall sales per month, and the right-hand side highlights the highest selling items by revenue (dictated by size).

Exhibit B – Business Pulse Dashboard: "Profits"
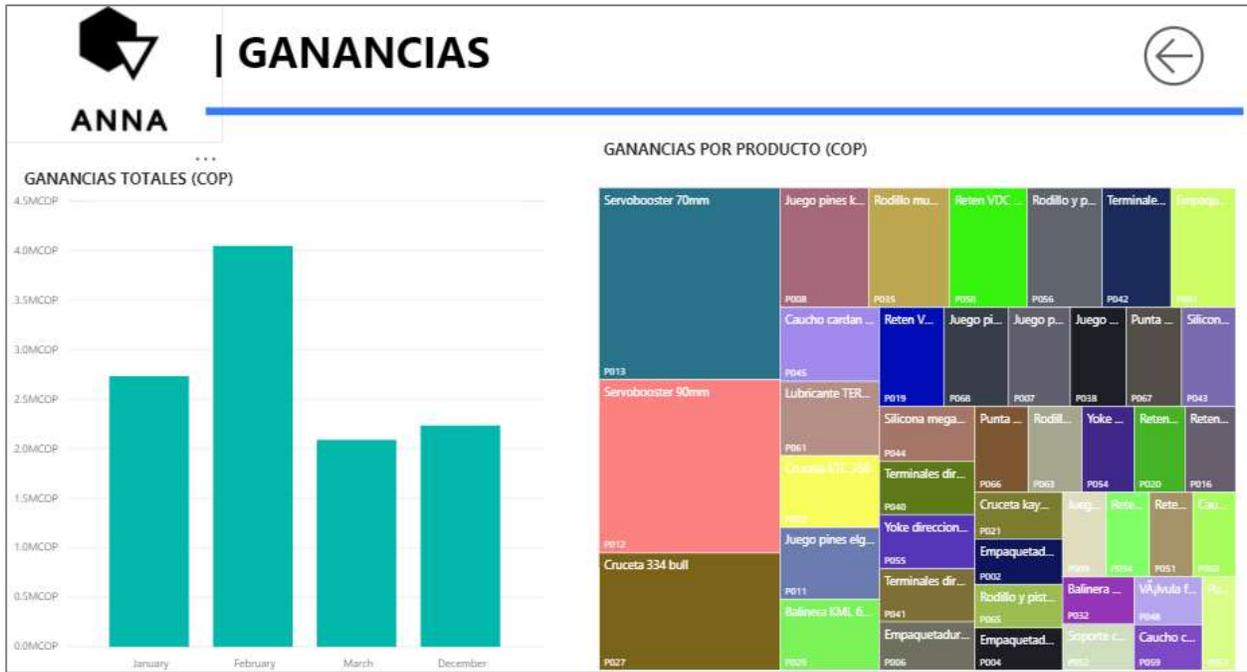
Profits (Ganancias): The second view is focused on profits, and it breaks down the profit per product as well as the overall percentage of profit each product brought in for a specified period of time.

Exhibit C – Business Pulse Dashboard: "Inventory"

Inventory (**Inventario**): The inventory view provides the business owner with a realistic estimation of how much inventory of each product is currently on-hand, as well as how much that inventory is worth in dollar terms. This is critical for them to understand because of the importance of cash in their operations and can help them choose where to focus their efforts if a cash influx is greatly needed.

Exhibit D – Business Pulse Dashboard: "Expenses"

Expenses (**Gastos**): The expenses view contains all additional expenses that the business needs for daily operations. These expenses can include rent, employee salaries, marketing, etc. By understanding total additional expenses, the owner has a better 360-degree view of how the business is performing and where revenue is being spent.

Exhibit E – Business Pulse Dashboard: "Balance"
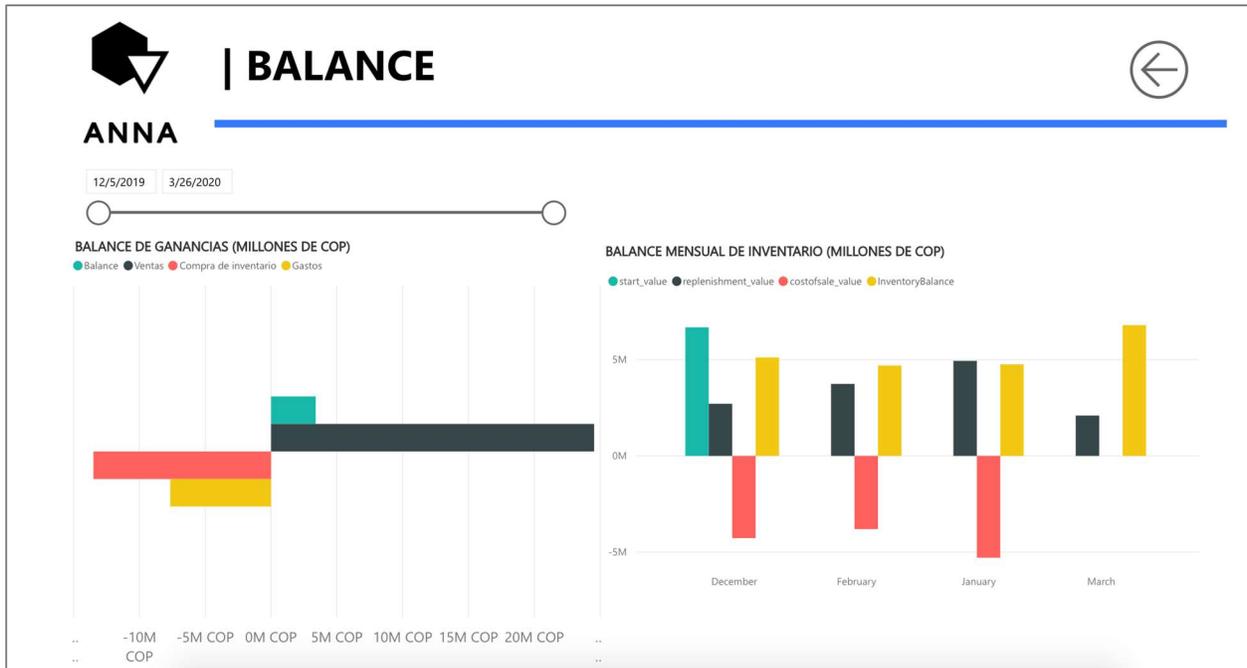
Balance (Balance): The last view in the dashboard contains a specified view of the cash balance over time. The cash balance is calculated by subtracting the amount spent in inventory replenishment and other expenses from overall sales.