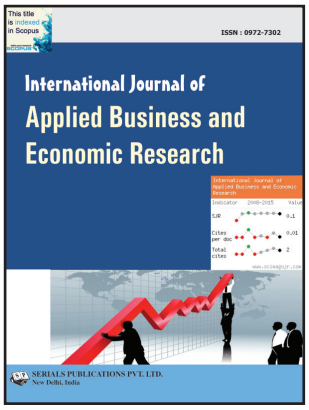

International Journal of Applied Business and Economic Research

ISSN : 0972-7302

available at http: www.serialsjournal.com

Volume 15 • Number 16 • 2017

Augmentation of Effectiveness of Vendor Managed Inventory (VMI) Operations with IoT Data – A Research Perspective

Samir Yerpude[1] and Tarun Kumar Singhal[2]

[1]*Research Scholar, Faculty of Management Symbiosis International University Pune, Maharashtra, India. Email: samiryerpude@gmail.com*

[2]*Professor (IT Management), Symbiosis Institute of Telecom Management Constituent of Symbiosis International University Pune, Maharashtra, India. Email: dr.tarun@rediffmail.com*

ABSTRACT

Objectives: To study the effectiveness of Vendor Managed Inventory (VMI) system enabled with IoT data.

Findings: Customer demands are continuously evolving and it is very relevant for all the organizations to align and keep pace with the change. VMI as a technique helps the organizations maintain a lean supply chain inventory and at the same time remain flexible to the customer demand. IoT data coupled with VMI not just supports the VMI piece of Inventory Management but also brings in the most crucial element of agility in the supply chain. This helps the organizations to remain competitive in the market and service the customers with a lean inventory without having stock-outs. This increases the customer satisfaction and gives a prominent edge to the organization unleashing various other potential areas.

Keywords: Vendor Managed Inventory, VMI, Inventory Management, Internet of Things, IoT.

1. INTRODUCTION

1.1. Vendor Managed Inventory (VMI)

The competition amongst the manufacturers is fierce in terms of supply chain and partially the success of the business model depends on the volume of inventory held. Inventory is the stock of goods or materials held by any business for the purposes of servicing or reselling to the customers. The management of the inventory from the point of entry until the point of exit within an organization is termed as Inventory Management. It is a discipline about physical stocking, stacking and placement of goods in a way that all the customersare quickly serviced and physical space is used optimally.This serves as a balancing act between focusing on optimizing or minimizing operational costs and maximizing profits (Hurdogan, 2010).

Fundamentally, Vendor Managed Inventory (VMI) is an add-on of Inventory Management also known at times as Consignment Inventory, which has evolved over a period. Figure depicts the evolution of Inventory management.

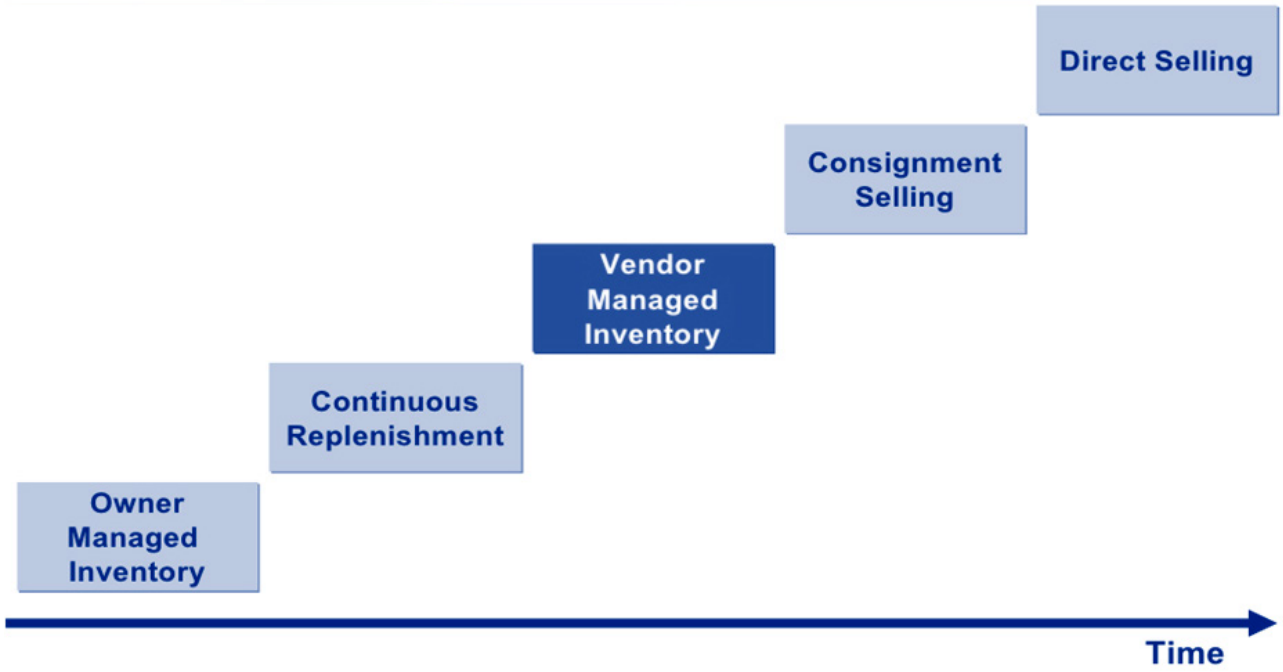

Figure 1: Evolution of Inventory Management (Subramanium, 2009)

VMI deals with a business practice where the vendors monitor and replenish their distributor inventory on appropriate levels as agreed with the distributor (Hurdogan, 2010). VMI is a technique where the vendor/ manufacturer is responsible for optimizing the inventory held by the distributor (Rouse, 2011). Apparently, this means that there is no need for the distributor to order on the vendor while his prime focus remains on selling and servicing customers. There are some classical inventory problems, which any organization faces while servicing or selling to the customers. The problem is, how much to produce?What to produce?VMI is significantly better at responding to the volatile customer demand due to any of the variations in the internal or external parameters(Disney & Towill, 2003). Primarily, VMI builds a collaborative platform between the manufacturer/vendor and the distributor to address the changing demand with greater agility. Profoundly,VMI differs from the conventional Inventory Management systems in the following ways:

1. It's a replenish pull system instead of a push system (Marques et al., 2008).
2. Vendor is responsible for the inventory held by the distributor (Marques et al., 2008).
3. There is a collaborative scope agreed (Marques et al., 2008).
4. The inventory norm is set and agreed between the vendor and the distributor.
5. It is a short- term scope, which is frozen and no long- term purchase order to the vendor (Marques et al., 2008).
6. The vendor has the visibility of the inventory at the distributor end.
7. Since no long-term purchase order or work order is involved, there is a target inventory level which is agreed (Marques et al., 2008).

1.2. Internet and Internet of Things (IoT)

Since VMI works on the collaborative platform, information sharing becomes extremely vital. It is very important to short circuit the information flow between the points of consumption to the vendor. The success solely depends on the coordination between the vendor and the customer irrespective of how independently operationally effective they are. This would undoubtedly require the fastest medium of communication *i.e.* Internet. Internet over the years has emerged as the potential channel of collating, storing and transmitting information over web. This became possible due to the innovations that happened in the Information Technology (IT) domain (Lou et al., 2011). The revolution influenced the industry in a positive and collaborative way as the information transferred amongst the organizations and their vendors (Lou et al., 2011). Today Internet is the fastest and most reliable means of sharing information for a supply chain resulting in effective and agile decision- making (Lou et al., 2011).

Internet has commanded an incontrovertible space in our lives, by virtue of its ubiquitous presence and impact on all business and technology aspects (Yerpude & Singhal, 2017). Billions of users are being served as the Internet has grown tremendously to a macro global network in the last five plus decades starting from a micro network (Yerpude & Singhal, 2017). **There were nearly 3.5 billion internet users worldwide in 2016 which means about 45 percent of the global population was able to access the internet in the same year. The global average internet speed stood at 6.1 Mbps that year (Yerpude & Singhal, 2017).** Billions of things are globally connected and communication of information is happening in an uninterrupted way (Kopetz, 2011). Among other influences, the most recent one is of Internet of Things (IoT).

Steenstrup and Kutnick (2015)define IoT as "a network of dedicated physical objects (things) that contain embedded technology to sense or interact with their internal state or the external environment". Rio and Banker (2014) define "IoT as connecting intelligent physical entities (sensors, devices, machines, assets, and products) to each other, to internet services and to applications".

2. LITERATURE REVIEW

2.1. Future of IoT

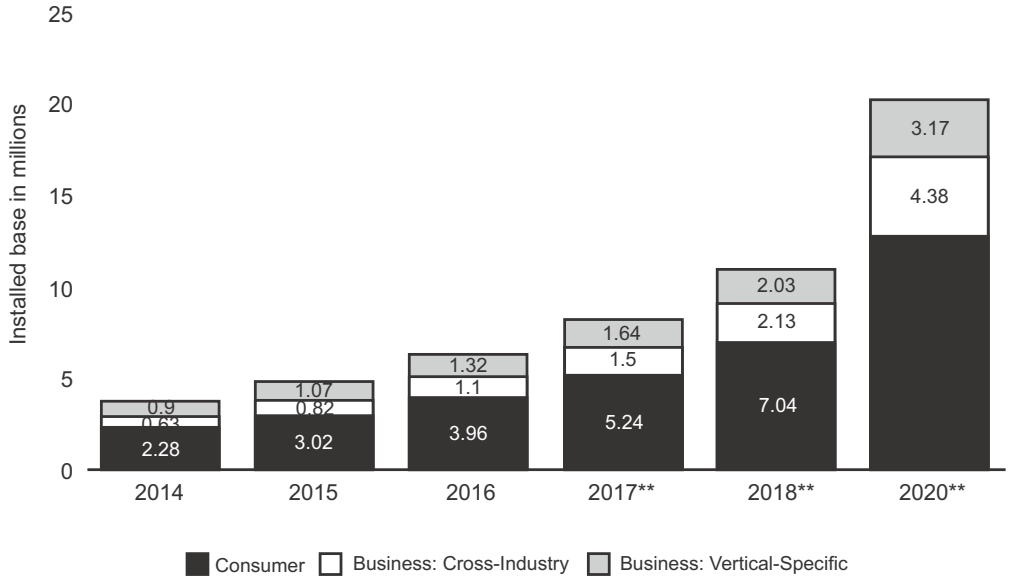

Figure 2: Installed base of the Internet of Things (IoT) by category between 2014 and 2020 (IoT installed base by category 2014-2020, *n.d.*)

Forecasts around the market values and number of devices show a rapid growth of IoT in the coming years (IoT installed base by category 2014-2020, *n.d.*). The global market value of IoT is expected to surpass 1 trillion USD mark by 2017 as compared to 600 billion USD mark in 2014 (IoT installed base by category 2014-2020, *n.d.*). The number of connected devices worldwide is projected to increase from around 18 billion in 2015 to 50 billion by 2020(IoT installed base by category 2014-2020, *n.d.*). The installed base of IoT devices is expected to excel from around five billion in 2015 to nearly 31 billion by 2020, with the consumer sector accounting for the majority of these units (IoT installed base by category 2014-2020, *n.d.*).

The above statistics indicate an extensive flow of real time data, which will affect the industry positively and help them in achieving agility and becoming more responsive to customer demand.

2.2. Objective of Strategic Alliance through VMI:

Distributor:

1. Higher consumer service level (Tang, 2006).
2. Lower inventory costs (Tang, 2006).
3. Maximize availability in order to maximize sales revenue and also market share
4. Responsive to volatile customer demand

Vendor:

1. Optimum production level
2. Reduced inventory level
3. Abridged transportation cost

Common Objective:

1. Better collaboration between partners (Holweg et al., 2005).
2. Agile supply chain (Holweg et al., 2005).
3. Reduction of Bull-whip effect (Holweg et al., 2005).

2.3. VMI Information framework

2.3.1. Traditional VMI Information flow

The traditional VMI information flow consists of a batch data transfer of stock between the distributor and vendor (Liu & Sun, 2011). Basis this information, the vendor does the forecasting of the requirement of parts and formalizes the production plan. This framework holds good when the product enjoys a monopoly in the market and the customer is willing to invest for a period. It also supports a static and a steady state of demand. In all other situations, the batch mode would lack the flexibility to accommodate the volatile demand and result in an incorrect forecast (Liu & Sun, 2011). In addition, most of the information in this framework is unilateral and flows from the distributor to the vendor (Liu& Sun, 2011). There is no communication back to the distributor about the vendor plans and hence can result in accumulation of obsolete inventory on either sides.

2.3.2. VMI Information Flow with IoT framework

Evidences have proven that implementation of a VMI system reduces the inventory carrying cost while on the other hand improves the supply chain performance with increased customer satisfaction. The data exchange that takes place between the vendor and distributor includes stock information, sales data, order status, forecasts, capacities and performance matrices signed off with the vendor (Liu & Sun, 2011). The flow is bi-directional as compared to the traditional information flow and hence needs extensive collaboration and real time data (Liu & Sun, 2011). It is humanly impossible to collect this data manually and hence systems like IoT come to rescue. IoT as collection of devices communicates and transfers data over the network and hasprimarily some amount of computational capability with sensors embedded (Comitz & Kersch, 2016). In a VMI system, the flow of information is huge and complex with multi-directional links between the vendor and the distributor. Real time information helps monitor the supply chain effectively and push the exceptional broadcasts all across the chain (Liu & Sun, 2011). These broadcasts are helpful for quick decision making and aligning the forecast to the volatility observed. It also helps build transparency and availability improving the level of co-ordination in the supply chain (Liu& Sun, 2011). Further, the data gathered from the IoT devices on parts movement helps the vendor categorize the inventory into Fast, Slow and Non-moving (FSN). FSN analysis helps reduce the inventory carrying costs and at the same time ensures the coverage of orders so that no shortages are reported (Neerkuzhi &Joseph,2013). The parts that are required frequently are termed as "Fast moving" while on the other hand the non- frequent requirement of parts pushes them in the "Slow moving" category. Parts having no consumption frequencies tagged as "Non- moving" parts(Neerkuzhi &Joseph,2013). Hence, it is imperative to focus more on the fast moving category as shortages in this category can be catastrophic and may lead to business losses.

2.3.3. Paybacks of VMI with IoT Information flow architecture:

There are various partnership strategies between the vendor and the distributors such as Quick Response (QR), Continuous Replenishment (CR) and Vendor Managed Inventory (VMI). We would record the paybacks of the VMI strategy coupled with the IoT information flow architecture in this section. VMI as a strategy is a strategic alliance where both, the vendor and the distributor, share the investment risk (Subramanium, 2009). With improved use of technology, the strategic growth in the market gets enhanced improving the top and bottom line for an organization (Subramanium, 2009). IoT information flow pumps in the requisite agility and flexibility in the system to respond to the evolving customer demands and turbulence flowing in from the market (Baarlid & Claesson, 2015). The stated need has drifted the organizations from lean trends to Agile Supply Chain Management (Baarlid & Claesson, 2015).Brewer and Speh (2000) state that "the companies which will be competitive in the future are distinguished by the ability to effectively coordinate their processes, focus on delivering customer value, eliminate unnecessary costs of key functional areas and create a performance measurement system that provides data on whether the supply chain is meeting the expectations or not". Recording and monitoring the data to enable the competitiveness of the organization is one of the biggest returns one can envisage from the VMI implementation augmented with the IoT information framework. Another challenging aspect in the VMI is communication. It enforces trust and commitment in the whole supply chain improving the overall performance of the entire supply chain (Lindner, 2009). Trust must exist between both the parties i.e. vendor and distributor as they have to satisfy the mutual goals of each other by sharing critical information to manage the alliance (Whipple & Frankel,2000). Automatic transfer of IoT data enables an unbiased transfer of data between the two ensuring the persistence of trust.

The following paybacks are visualized'with respect to the pain points of Inventory Management.

Traditionally any organization has to face the following challenges in the supply chain operations:

1. Reactive Management due to late notification of events, which are likely going to affect the inventory (SCM Desk, 2014).
2. The uncertainty in demand leads to excess inventory while uncertainty in supplies leads to speculative ordering (SCM Desk, 2014).
3. Increased levels of costly year-end write offs due to excess inventory (Sutter, n.d).
4. Productive time lost in planning and communication of orders (Çetinkaya & Lee, 2000).
5. Critical and vital information is not available when needed resulting in lost sales, stock outs and discounted sales (SCM Desk, 2014).
6. Lower Inventory Turns (Subramanium, 2009).
7. And, rigid to evolving customer demands as there is a lag in the alert going until the vendor (SCM Desk, 2014).

We discussed on the paybacks of the IoT augmented Vendor Managed Inventory system. In this section we shall critically examine and witness the set-offs of the above-mentioned pain points with the IoT data augmented VMI. The key benefits derived by the organizations with the implementation include:

1. Proactive Management with the communication reaching right until the vendor near real time (Subramanium, 2009).
2. Much richer data, which enhances the forecasting accuracy and brings predictability in the supplies (Çetinkaya & Lee, 2000).
3. Lesser write-offs on account of obsolescence and better cash flows as the inventory is managed by the vendor for the distributor (Sutter, n.d).
4. The long term planning is avoided with no individual purchase order requirement saving time for much more effective short term planning (Çetinkaya & Lee, 2000).
5. Huge amount of trust gets built in the supply chain where there is a bi-lateral communication between the vendor and the distributor turning the engagement in a win-win situation for both (Çetinkaya & Lee, 2000).
6. Higher inventory turns with excellent management of economic order quantity and an agreement on the inventory norms (Subramanium, 2009).
7. Flexibility and agility are inbuilt in the system to address the volatile customer demand (Çetinkaya & Lee, 2000).

From the above discussion, we can envision how the IoT data augmented VMI system scores over the pain points of the Supply Chain. Summarizing the above points, the comparison is seen as below:

Table 1
Supply Chain Pain point's v/s IoT augmented VMI System

Pain Points of Supply Chain	*Benefits of using IoT augmented VMI System*
• Reactive Management	✓ Proactive approach
• Volatile Demand & Speculative Ordering	✓ High forecasting accuracy
• Costly Year end write-offs	✓ Lesser write offs and Better cash flows
• Time spent in planning and ordering	✓ Planning and ordering time is saved
• Delayed information resulting in Sale Loss due to stock outs and discounted Sales.	✓ Huge trust because of transparency in the system
• Lower Inventory Turns	✓ Higher Inventory turns and better inventory management
• Rigid to evolving customer demand	✓ Higher customer responsiveness, Higher Customer satisfaction

The Impact of IoT data-based VMI on the Key Stake holders is depicted in the fig below. The fig demonstrates the contribution of the IoT data- based VMI system in the whole ecosystem affecting the major key stake- holders.

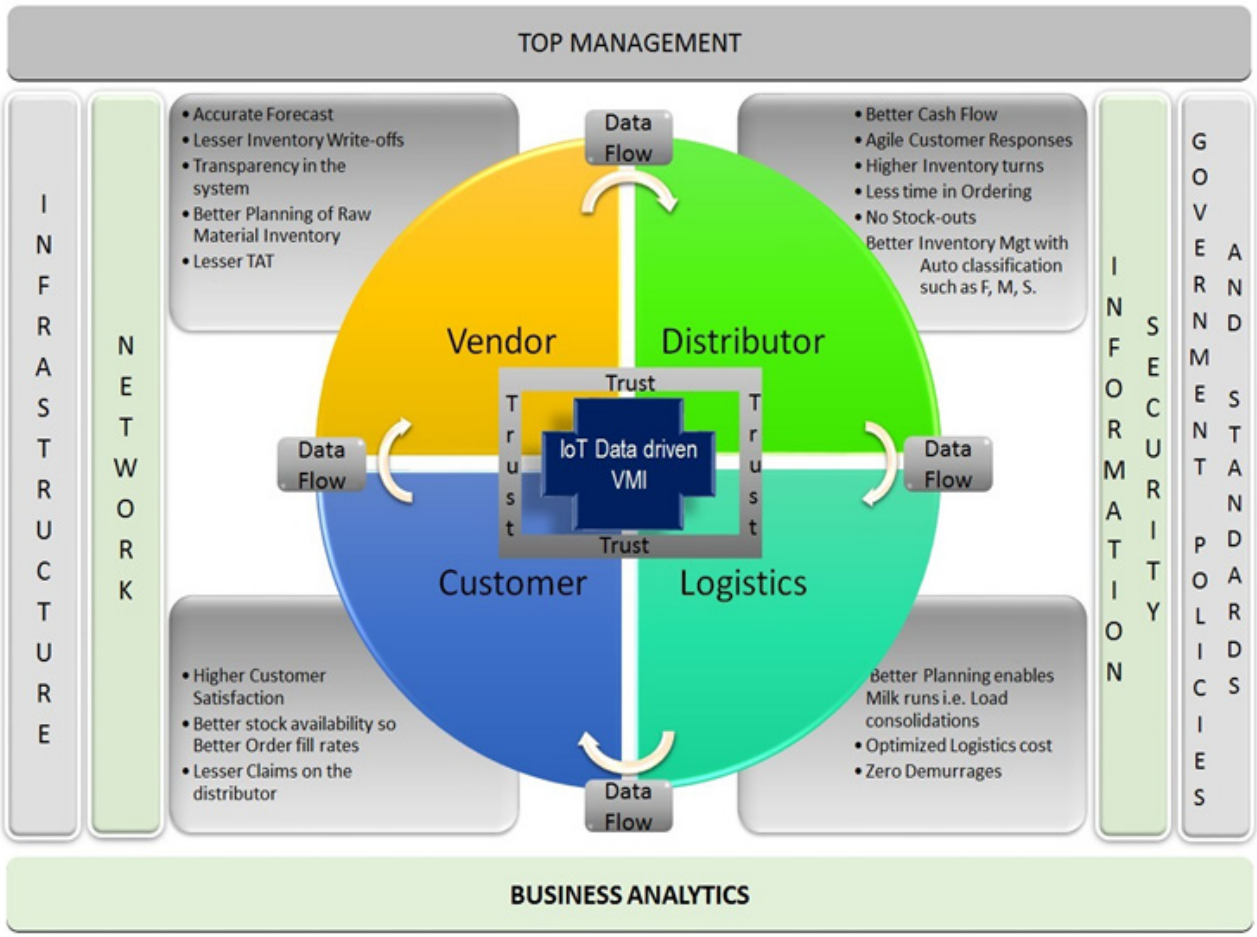

Figure 3: The IoT data driven VMI Framework and the impact on Key stakeholders

To emphasize and elaborate more on the benefits lets deliberate on a case study.

Case Study(Bansal, 2009): The organization in subject is Marico, listed in Forbes India's Super 50 Companies. Founded in 1991, the company has a CAGR of 13% in turnover & 15% profit over the last 5 years. Has 12 brands, 100 SKU's (Stock keeping units), 7 factories, 1000 distributor and 20 Lakh plus retail outlets reaching 13 crore consumers.The strategy adopted by Marico included understanding and anticipating consumer needs while innovating to meet the customer needs. They believed in making the availability of the products really wide, and track the performance matrices to support positioning of their products. The business matrices reported by Marico's were Forecast accuracy of 70%, Stock-outs and loss of sales on 30% of the SKU's, Excess inventory and costly errors in shipment. The challenges in their supply chain were conventional in nature with penetration in less than 20,000 population. No secondary sale data was available. The Skew of sales in a month in ratios was 10:28:62.There were data visibility issues with distribution network complexity. The peak/minimum sales ratio variation across the year was high as 3:1.

Implementation of VMI as a Supply Chain technique with data visibility throughout the system was completed. There was a phenomenal turn-around story for Marico's. The peak/minimum sales ratio variation came down to acceptable limits when compared with the previous figure of 3:1.

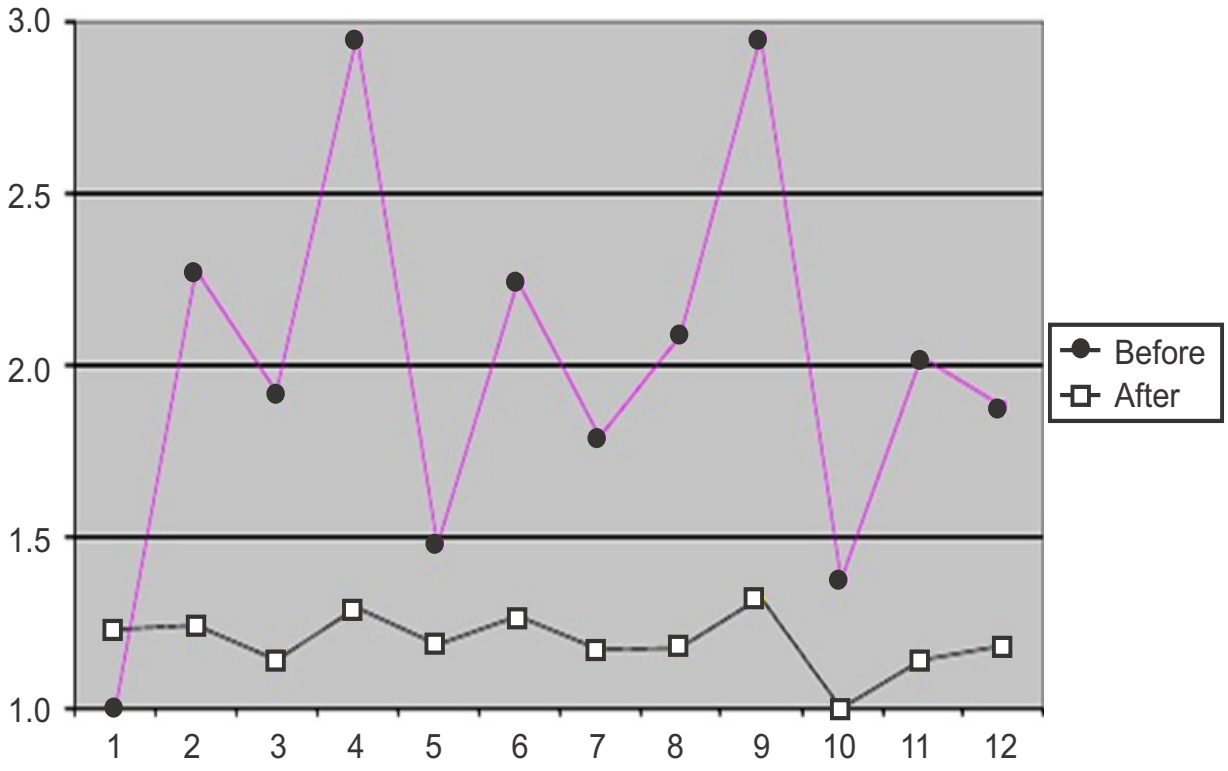

Figure 4: Peak/Minimum Sales ratio variation across the year - As high as 3:1 before the implementation with the same Average Sales(Bansal, 2009)

The Sales Skew reduced with the decrease in stock outs by 50%.

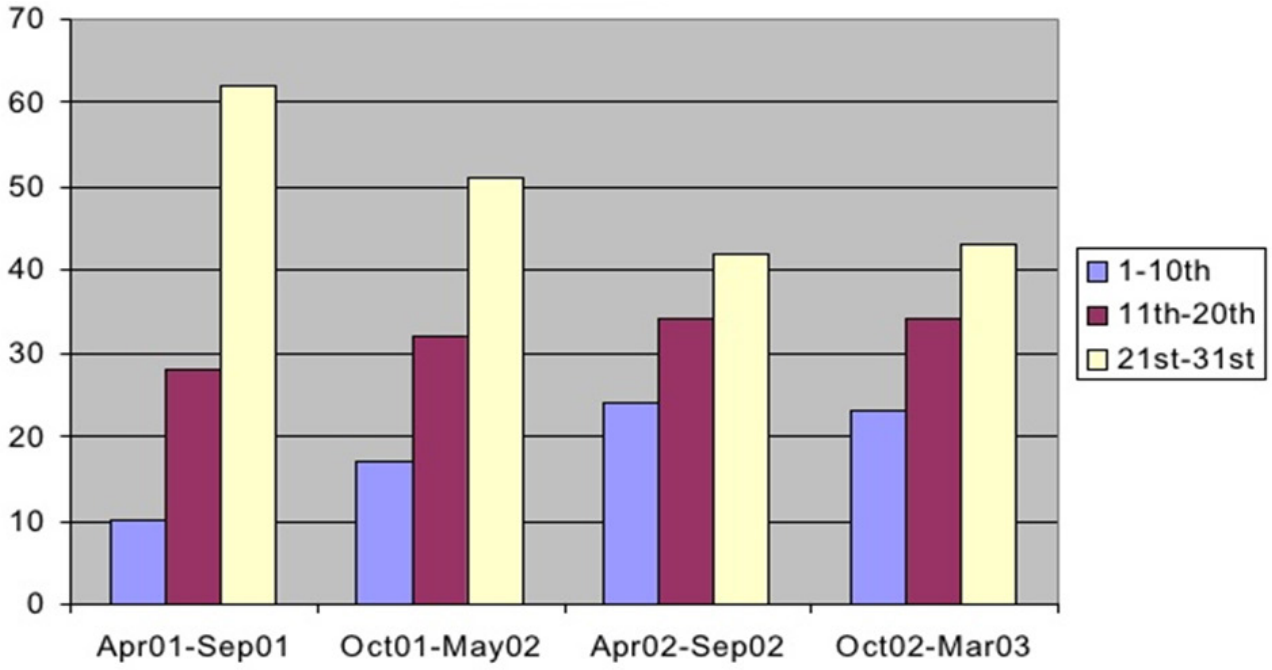

Figure 5: Block-wise Sales skew change from 10:28:62 to 24:34:43(Bansal, 2009)

While excess inventory at distributors was reduced by 50%, Marico's average total inventory reduced by 25% with the supply chain exception handling cost reducing by 60%.

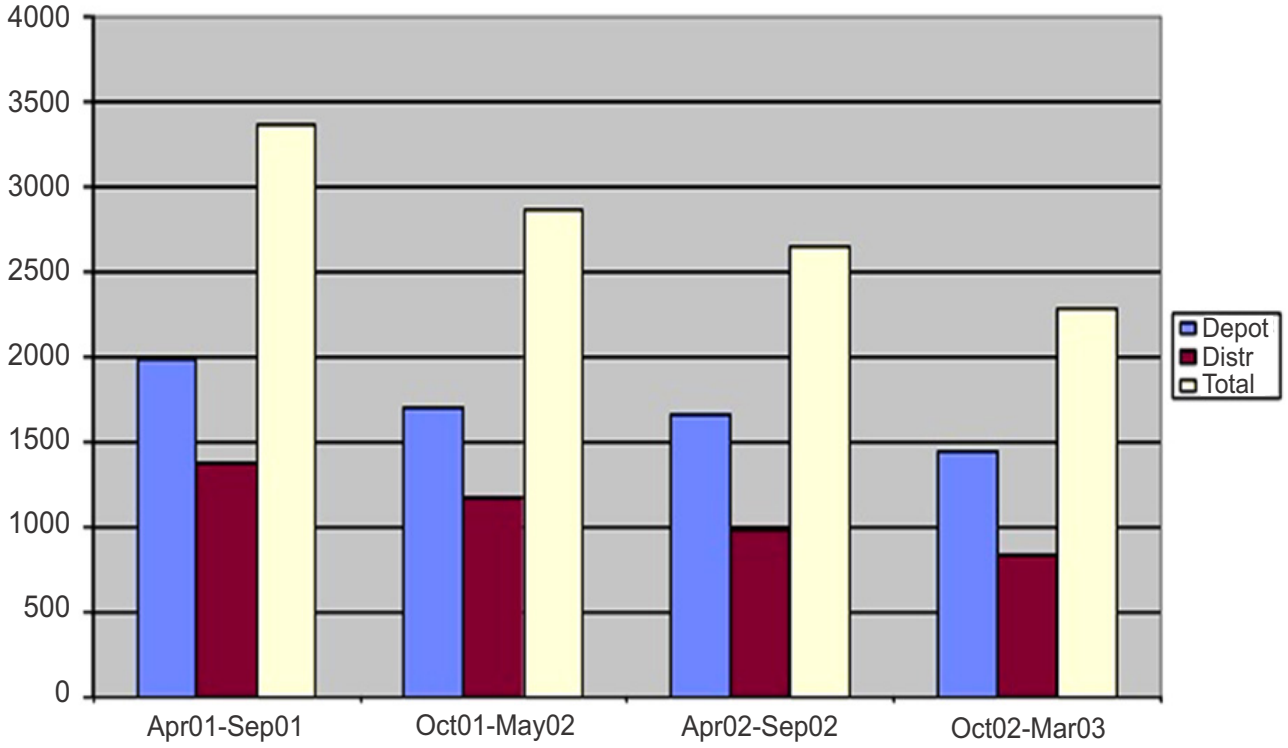

Figure 6: Trend of Reduction in Depot, Distributor and Total Inventory(Bansal, 2009)

The turn-around ensured funding for advertisements with greater sales productivity. The company continued to ride on the double- digit growth numbers for earnings and revenues with the distributor service level reported to have increased from @74.5% to max of 81.8%, a whooping increase of 7.3%.

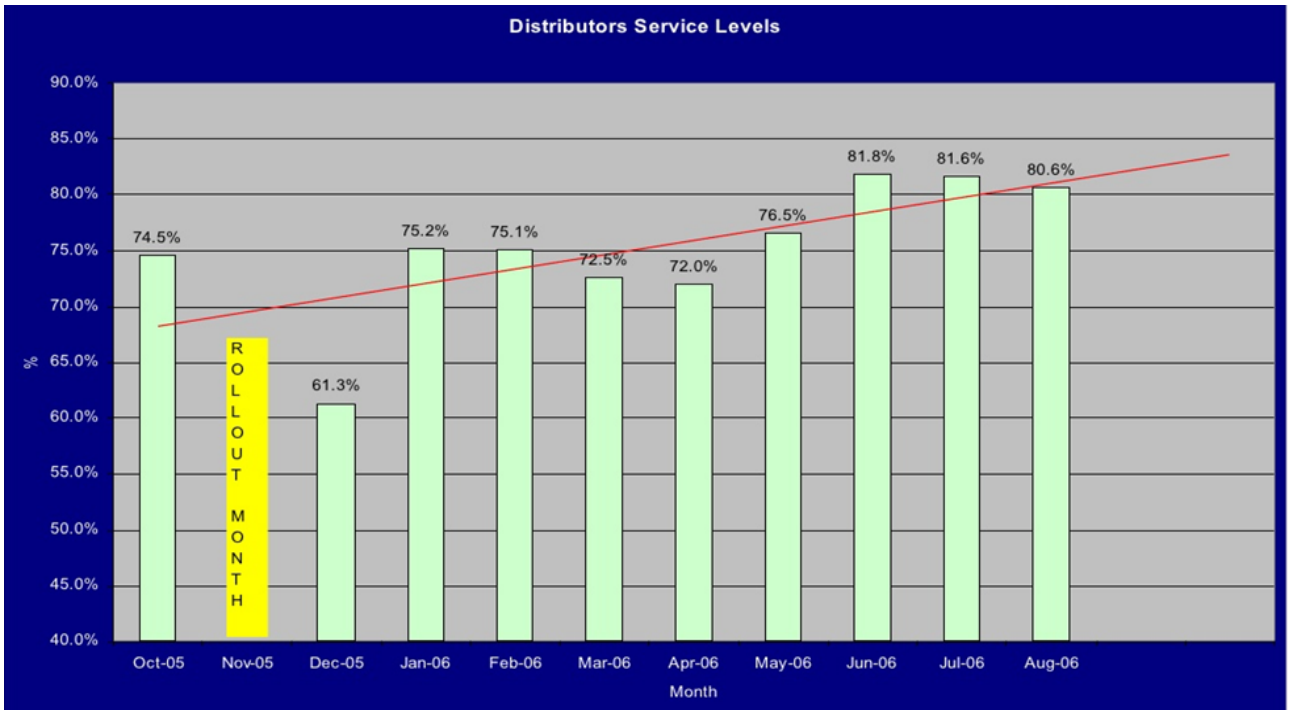

Figure 7: Improvement in Distributors Service Levels(Bansal, 2009)

3. CONCLUSION

Analyzing the evolving customer demand is a challenge for any organization today. The solution lies within the organization of building an agile supply chain, which cuts all the inefficiencies in the system, reduces the cost of inventory (ownership) and improves the customer service. In today's world, the existence of an organization depends upon the satisfaction of its customers. This can be achieved by being flexible to the customers. While there exists a fierce competition in the market, techniques like Vendor Managed Inventory (VMI) or consignment inventory coupled with IoT data framework will help retain competitive edge and even excel in the market. VMI offers substantial benefits to the vendors such as lower customer service cost, better forecasts with reduced stock-outs, improved cash cycles and improved customer loyalty. On the distributor front, some crucial benefits include reduced working capital, assured product supply, reduced demand uncertainty, fewer distress purchases and lower planning & ordering costs.

The challenges in implementation of VMI with IoT framework include arriving at an agreement with the vendor, setting the right inventory norms and the infrastructure required to set up the IoT framework. Defining the right performance matrices/parameters is also equally vital. The common performance measure includes parameters such as inventory value, inventory turns, before, during and post the implementation. Service parameters encompass order fulfillment percentages, number of stock-outs etc. and financial parameters cover the aspects such as cost reduction, revenue growth and gross margin. These are very crucial and should be monitored and managed on a regular basis.

Post the initial investments of time, money and energy in building the system, the return on investments of this system look pretty lucrative and beneficial for an organization.

4. RECOMMENDATIONS

IoT since inception is evolving unceasingly. There are quite a few used cased where IoT data is consumed in a business model, VMI being one of them. Previous section, Paybacks of VMI with IoT Information flow architecture, emphasizes on the benefits derived by the implementation of this system. While today the world has entered the Industrial revolution 4.0, IoT currently is enabling business in creating new business opportunities in the following 5 ways:

1. IoT helps creates new value streams in the business for customers with undisputed response to volatility (Schmarzo, 2014).
2. Key Parameters for an organization such as Operational efficiency, Customer Loyalty etc. can only get formulated with the mission critical data from IoT (Schmarzo, 2014).
3. IoT data can help unleash certain business areas, which are unexplored and can build new revenue streams over the existing traditional business streams (Schmarzo, 2014).
4. IoT data enables the visibility not just within the business but gives a sense of global performance since it tracks the supply chain efficacy and efficiency (Schmarzo, 2014).
5. IoT data because of the being real time aids the decision makers to take online decisions, which are on the fly changes to the governing parameters (Schmarzo, 2014).

Since the digital business focuses on customer first principle, it becomes extremely significant to possess the real time information of the customer. The real time information would include the customer choices, demands, changing trends and grievances. This is only possible with a system where the data is gathered from automatic sensors fixed at appropriate data gathering spots and stored in a data warehouse to perform business analytics. There are five major criteria to extract maximum value from the data gathered. The data should hold well on ease of access, real time, foot- print, transformative and intersection synergies. To enable the IoT system, there are three main components.

1. Hardware comprising of sensor, actuators and embedded communication hardware.
2. Middleware for storing the data and doing analytics
3. Presentation Layer for representing the results from analytics.

While all the above-mentioned components fall in the capital expenditure domain, it is the IoT set-up cost, which is delivering the paybacks as mentioned in the previous section. More so, the prime focus of the organization is shifted from product, process to the customer augmenting the customer loyalty and stickiness of the customer to the organization. The result is a customer focused, profit making healthy organization having the zeal to enter into new revenue streams because of the IoT data provisioning. Hence, the researchers recommend IoT data enabled VMI as a strong case for implementation.

5. FUTURE WORK

Quarrying the future of IoT, we realized that in 2014 the percentage of data consumed from embedded systems was only 8% of the "Target rich data"(Nabulsi, 2014). The contribution of this data is expected to reach 21% by 2020 (Nabulsi, 2014). The number of connectable things is also targeted to grow to 15%, from a meager 7% in 2013 (Nabulsi, 2014). The top two sectors in terms on investing in IoT solutions are:

1. Manufacturing (Ju et al., 2016)
2. Transportation and Warehousing (Ju et al., 2016)

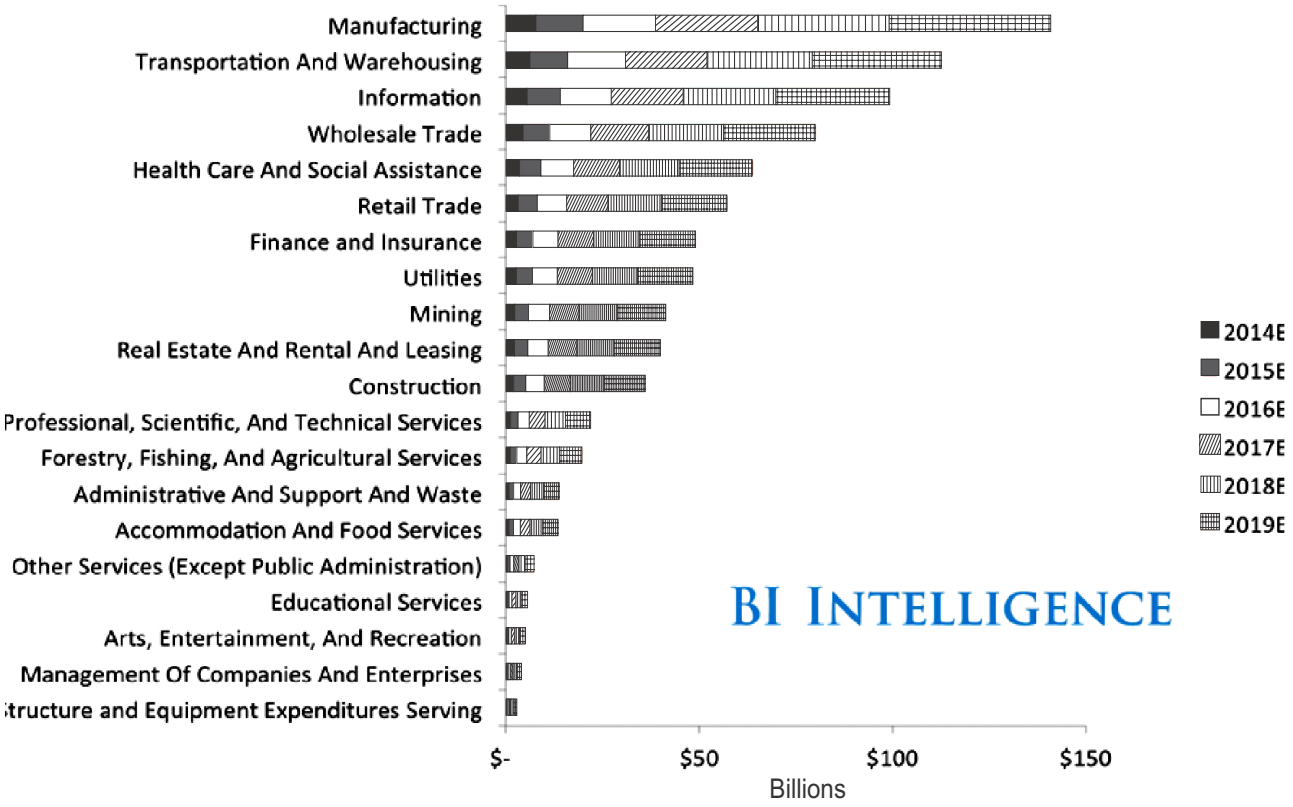

Figure 8: Investments in IoT solutions by Industry(Ju et al., 2016)

VMI with IoT data is definite to bring in a revolution in both the above sector with the growth in IoT, making us witness a turnaround in the sector performance indexes. The research conducted by the researchers is limited to the study the impact of the data generated by IoT on the VMI system and its benefits derived by the key stakeholders, vendor and distributor.

Future research directed in this area should focus on the impact on other stakeholders such as Logistics service provider and the entire eco-system involved. Some of the research questions to be answered would be, how can the same alert be sent to different stakeholders and it will mean a different set of actions for each one of them?Second research objective, which can draw from the study, is to calculate the ROI and compare it with the investments made by the organization to arrive at the break- even point.

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