# Integration of technology in production activity, a new approach to an old problem

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**Abstract:**

The current retail sector in India is expanding quickly, the current inventory management methods require transformation. In retail inventory management structure tagging and tracking is an important inventory management process. The current tagging and tracking process is people driven and therefore susceptible to human error. The present research is an exploratory experimental study which includes the analysis of 2 different approaches to small retail sector inventory management. The research will measure the effectiveness of both approaches by testing them in a controlled environment and evaluating their effectiveness based on the data collected. The findings of the research are that a significant difference was found *in the completion of the tagging and tracking tasks performed by experienced professionals and IMI(Inventory management intelligence software)*, and *furthermore a significant difference was also found between the accuracy of the tagging and tracking tasks performed by experienced professionals and IMI.* The economic and business implications are valid in India especially due to preference of labour combinations over specialised physical capital based production combinations, due to low price of labour in India. There are several implications regarding technological advancement and structural changes in industry mainly relating to changing possible changes in the combination of production processes. In short, the future of the small retail sector is process driven and not people driven. However, structural changes in any industry impacts stakeholders, in this case the employees. Such technological advancement threatens jobs in future, pursuing in this direction may become an ethical concern, as this may cause structural unemployment.

**Keywords-**

*Tagging and tracking, IMI, Retail sector pop up, Inventory management intelligence.*

**Introduction-**

Tagging seems simple in essence as how long would it take to put the tag on? But, that is not the case, tagging and tracking in inventory management is usually a 10 step long process depending on a firm's internal procedures (Luther, 2020). The average inventory management process is complex due to the tangential process that work alongside it (Luther, 2020), difficulty arises when a firm tries to integrate their process together.

Moreover, it is vital to look at challenges in this smaller section of the retail industry because the small retail stores (pop-up business model) dominate the $900 billion dollar retail industry (Reuters, 2021). Moreover, with current management systems this huge industry faces a common set of challenges. For example, supply chain management is a big issue (Chhillar, 2016), especially if the pop ups don't own their own inventory. Furthermore, small pop-ups (the business model) usually perform manual documentation which is extremely tedious(Jenkins, A, 2021); insufficient order management as they may run out of stock, this will increase customer wait time(Jenkins, A, 2021), posing an issue from a marketing standpoint too. In addition poor management can lead to inventory loss(Jenkins, A, 2021). Therefore, the small retail sector is driven by these major issues listed above.

The solution to such a problem may sound easy. Why not integrate manual processes with technology and reduce errors? However, in this sector of the retail industry good solutions barely exist. Infact, current management solutions are low tech and complicate the process even more (Jenkins, A, 2021). Moreover, firms face additional issues due to inadequate software like ‘need for training’ and poor communication (Jenkins, A, 2021). These ‘lack of technological expertise’ can have a negative impact on business like diseconomies of scale on initial adaptation.

This research study will test out a new computer system’s approach to small retail sector inventory management. The software has been specifically crafted for the small pop up retail sector market called the inventory management intelligence. This makes sure that the solution is adequate enough to solve the issues listed above.

An experiment will be conducted which will compare the manual industry standard approach to the new technologically advanced and focused IMI. The aim is to evaluate the effectiveness of IMI based on time and accuracy.

**Methodology**

Research approach:

The aim of the research study was to evaluate the effectiveness of Inventory Management intelligence (IMI), a self-designed inventory management software, in reducing man hours and errors that typically occur in the process of tagging and tracking inventory through a mixed method approach. More specifically, time and accuracy of both approaches to tagging and tracking across 3 data sets of 5 trial runs for varying quantities of inventory (10,20,30, and 40). In each trial run both approaches will engage in a head to head 'competition' where they compete (in the premise of speed and accuracy) in the same control environment.

*Approaches :*

1. *The industry standard approach in India, which involves using a team of two people in a proper control environment to perform the complete tagging and tracking process.*
2. *The second approach involves the inclusion of (IMI) software with a team of 2 people to complete the tagging and tracking process in the same controlled environment.*

**Research design :**

An experiment was performed in a controlled environment using both approaches. Dependent variables include Time and accuracy. Independent variables included the size of the team (resources used IMI included or not) and the number of inventory items.

The control environment strictly focused on the tagging and tracking process. Therefore, the process of selecting dresses was already done. Moreover, all the tools required to complete the task were already arranged so random errors in our data can be eliminated.

**Hypothesis:**

Under the quantitative approach, the hypotheses are as follows:

- *<u>Null Hypothesis 1</u>: There are no differences between the mean number of man-hours in the completion of the tagging and tracking tasks performed by experienced professionals and IMI.*

  *<u>Alternative Hypothesis 1</u>: There is a difference between the mean number of man-hours in the completion of the*

*tagging and tracking tasks performed by experienced professionals and IMI.*

- *Null Hypothesis 2: There are no differences between the mean accuracy in the completion of the tagging and tracking tasks performed by experienced professionals and IMI.*

  *Alternative Hypothesis 2: There is a difference between the mean accuracy in the completion of the tagging and tracking tasks performed by experienced professionals and IMI.*

**Consent and Ethical Issues**

Informed consent was taken from the tagging and tracking team for data collection. Confidentiality and privacy of the respondents were maintained; no data would be disclosed to a third party. No identifiers such as name or pictures were disclosed in the article or while conducting the study. Ethical guidelines of research were followed.

**Tools used:**

To better understand this process visualise the operations of a retail business this process is used in imaging that you run a small retail company, where you essentially provide a marketplace for other brands and clothing labels. Your company borrows its inventory from another firm which comes with important responsibility making sure that every item is accounted for or "tracking". How tracking is done is usually by labeling each piece of inventory and maintaining a database or a record by declaring a primary key which corresponds to attributes of each item borrowed. This is an important process since if you lose those items your business will be responsible for the losses incurred by lending business.

Now tracking traditionally is done by assigning each piece of inventory a unique identifier. A unique identifier could be anything from numbers to alphanumeric code.

**Figure 1. Database sample**

| ID | VARIATION | DESCRIPTION | CATEGORY | PRICE | ORDERLEVEL | REORDERLEVEL |
|---|---|---|---|---|---|---|
| 1 | A | Red colour | Clothing | 500.0 | [redacted] | 50 |
| 2 | A | Black colour | Clothing item | 5000.0 | 170 | 50 |
| 2 | B | Green colour | Clothing item | 5000.0 | 136 | 50 |

Now tagging refers to attaching this identifier (primary key) to the physical piece of inventory. This process is executed by creating a 'tag' which has the primary key and important attributes printed on it. The database above is the tool used to track items. It stores key information about order level and reorder level which are used in inventory management. Moreover, additional details like description, price, and category and a primary key are used to differentiate among the information in the database. This process needs to be done

accurately for each inventory item for a successful process.

**Figure 2. Sample Tag**


The ID and variation combined are the primary key credentials which can be used to track this specific item using the database. Moreover, this specific tag contains the secondary attributes (DESCRIPTION, CATEGORY, and PRICE). Note the inclusion of secondary attributes on a tag isn't necessary, however, it is a practice which is seen in the fashion business. They use it to display frequently asked information by the customers.

**Data collection procedure:**

Approach one -

For this approach a team of two technical people recruited to complete the tagging and tracking process. The team was assembled and briefed about the task and the inventory they would be tracking and tagging. The team was asked to fill in the database manually to track all the products. This database chart required the exact details represented in the database. They were also required to enter tagging details represented in sample tag in and use the tagging gun to [physically tag each inventory item. They were instructed to finish this process for a varying number of inventory (10, 20, 30, 40) which meant the team tagged and tracked a total of 100 inventory items in one trial run. The team was asked to complete a total of 3 trial runs in which they tagged and tracked a total of 300 items. During each trial run time taken to finish each number of inventory and accuracy was collected.

Approach two -

For this approach a team of two technical people and IMI were recruited to complete the tagging and tracking process. The team was assembled and briefed about the task, using the features of IMI to finish the task this time ,and the inventory they would be tracking and tagging. The team was asked to fill in the database on IMI's interface. IMI's required the exact details

represented in the database. Then they used a printer to print tags directly from IMI and a tagging gun to physically tag the inventory. They were instructed to finish this process for a varying number of inventory (10, 20, 30, 40) which meant they team tagged and tracked a total of 100 inventory items in one trial run. The team was asked to complete a total of 3 trial runs in which they tagged and tracked a total of 300 items. During each trial run time taken to finish each number of inventory and accuracy was collected.

After the data was collected then graphs and tables were used to showcase visual comparisons, then t tests were run on the data with regards to time and accuracy for varying numbers of inventory(10, 20, 30, and 40). To confirm the hypothesis.

**Results and Discussion:**

**Table 1-** Time (minutes) and accuracy related data collected from 3 trial runs. Time 1 refers to time taken to tag and track 10 inventory items, similarly time 2 is for 20 items, time 3 is for 30 items, and time 4 is for 40 items.

| Approach | Trial number | Time 1 | Time 2 | Time 3 | Time 4 | Accuracy |
|---|---|---|---|---|---|---|
| 1 | trial 1 | 23.46 min | 31.59 min | 39.28 min | 46.15 min | 18 |
| | trial 2 | 19.26 min | 28.56 min | 35.08 min | 42.55 min | 14 |
| | trial 3 | 22.43 min | 30.47 min | 37.58 min | 44.55 min | 17 |
| 2 | trial 1 | 12.35 min | 19.05 min | 25.47 min | 31.37 min | 5 |
| | trial 2 | 14.15 min | 21 min | 27.57 min | 32.37 min | 8 |
| | trial 3 | 11.23 min | 18.41 min | 24.5 min | 30.21 min | 3 |

The table above showcases results of the controlled trials conducted for the Industry Standard *approach 1* and IMI *approach 2* Each trial consisted of a total of 100 products. The above table is a record of the time it took for each approach to tag and track 10, 20, 30, and 40 items. The time 1 (*in table 1*) corresponds to the time taken to tag and track 10 items, time 2 (*in table 1*) corresponds to the time taken to tag and track 20 items, time 3 (*in table 1*) corresponds to the time taken to tag and track 30 items, and time 4 (*in table 1*) corresponds to the time taken to tag and track 40 items. Moreover, the table also showcases the accuracy (defined in glossary) in each of the 3 trials for tagging and tracking 100 inventory items.

The contents of the table 1 under each time segment 1, 2, 3, or 4 are a record of minutes. For

example, under time1 and trial 1 for approach one means that using this approach in the experiment's first trial the team tagged and tracked 10 inventory items in 23.46 minutes, then in the same trial using the same approach under time 2 the team tagged and tracked 20 inventory items in 31.59 minutes, under time 3 the team tagged and tracked 30 inventory items in 39.28. Under time 4 the team tagged and tracked 40 inventory items in 46.15 minutes. Similarly for approach 1, trial 2, time 1 = 19.26 min, time 2 = 28.56 min, time 3 = 35.08 min , time 4 = 42.55 min. For approach 1, trial 3, time 1 = 22.43 min, time 2 = 30.47 min, time 3 = 37.58 min, time 4 44.55 min.

Now for approach 2, trial 1, time 1 = 12.35 min, time 2 = 19.05 min, time 3 25.47 min, time 4 = 31.37min. Trial 2, time 1 = 14.15 min, time 2 = 21 min, time 3 = 27.57 min, time 4 = 32.37 min. Trial 3, time 1 = 11.23 min, time 2 = 18.41 min, time 3 = 24.5 min, time 4 = 30.21 min.

As it is visible that the time data for both approaches are extremely different for both parameters. The trend of the data has been plotted on a graph below for further comparison (figure 3).

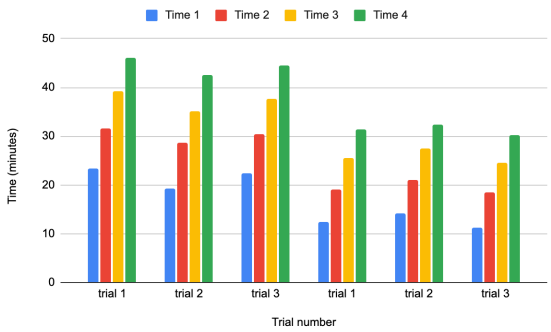


**Figure 3.** Time taken for tagging and tracking of each individual bracket of inventory.

The first three trials of the table represent the finalised results for Approach one, data is shown in Table 1 above. The last 3 trials represent the finalised results for Approach two. This can be used to make comparisons; example in trial 1, time 1 time taken to tag and track 10 inventory items, approach one took about 23 minutes and approach two took 12 minutes. Moreover, one can make comparisons across trials from the same approach as in trial 2 for approach one the time taken to tag and track was 19 minutes approx which is lower than the first trial. Furthermore, for trial 3 for the same approach one the time taken to tag and track the same number of items took 22 minutes approx.

Visually there is a clear difference in the time it takes to tag and track each inventory item between the two approaches. Clearly IMI has added a time advantage to the tagging and tracking process.

In table 2 & 3 the mean time for both approaches has been tabulated for comparison. This has been done by adding the total number of taken for each inventory across all 4 inventory brackets (10,20,30 and 40). The mean times for both approaches are showcased below.

Now a comparison of both approaches 1 & 2 can be made using the mean timing of all the 4 times (time 1, time 2, time 3, time 4) for the 4 inventory brackets (10,20,30,40). The mean has been calculated in the table 2 and 3 below in green.

**Table 2.** Mean time calculated for approach 1-

| Trial number | Industrial 1(Trial) | Industrial 2 (Trial) | Industrial 3 (Trial) | Mean of all 3 trials Ind. |
|---|---|---|---|---|
| Time 1 | 23.46 min | 19.26 min | 22.43 min | 21.72 min |
| Time 2 | 31.59 min | 28.56 min | 30.47 min | 30.21 min |
| Time 3 | 39.28 min | 35.08 min | 37.58 min | 37.32 min |
| Time 4 | 46.15 min | 42.55 min | 44.55 min | 44.42 min |

**Table 3.** Mean time calculated for approach 2-

| Trial number | IMI 1 (Trial) | IMI 2 (Trial) | IMI 3 (Trial) | Mean of all 3 trials IMI |
|---|---|---|---|---|
| Time 1 | 12.35 min | 14.15 min | 11.23 min | 12.58 min |
| Time 2 | 19.05 min | 21 min | 18.41 min | 19.49 min |
| Time 3 | 25.47 min | 27.57 min | 24.5 min | 25.85 min |
| Time 4 | 31.37 min | 32.37 min | 30.21 min | 31.32 min |

A sample calculation for the mean: in IMI for Time 1 which corresponds to time taken to track ten inventory items you must add the times taken in each trial and divide it by 3

Below a line graph visually showcases the difference between the mean time for each inventory bracket.

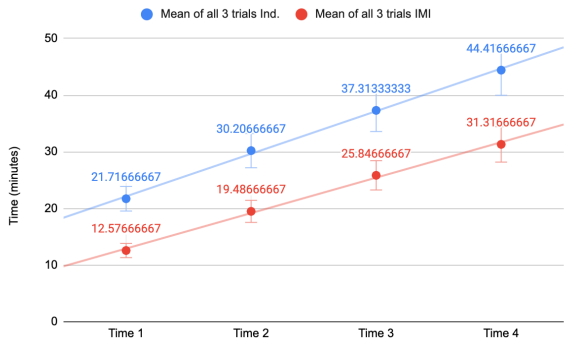


**Figure 4.** Mean times for each inveontry bracket of all 3 trials for approach 1(Ind) and approach two (IMI)

Through the graph (figure 4) above we can make comparisons between the mean teams for both approaches for time taken to tag and track

different inventory brackets (10,20,30 & 40). The mean time it took to tag and track 10 items by approach 1 was 21.7minute and approach 2 was 12.6 minutes. The mean time it took to tag and track 20 items by approach 1 was 30.2 minute and approach 2 was 19.5 minutes. The mean time it took to tag and track 30 items by approach 1 was 37.3 minute and approach 2 was 25.8 minutes. The mean time it took to tag and track 40 items by approach 1 was 44.4 minute and approach 2 was 31.3 minutes.

In the graph above (figure 4) the blue line represents the results of approach 1 and the red line represents the results of approach 2. There is a clear distinction between the mean time statistics of both approaches. Since both trend lines are linear and it is difficult to determine the actual variance just looking at the graph, a t -test will help us determine which hypothesis is correct.

**Table 4.** Data collected regarding accuracy (defined in glossary) in each trial for both approaches.

| | **Acc. Ind. (Approach 1)** | **Acc. IMI (Approach 2)** |
|---|---|---|
| **trial 1** | 18 | 5 |
| **trial 2** | 14 | 8 |
| **trial 3** | 17 | 3 |

The table above showcases the accuracy results or the number of mistakes that fit the criteria defined in the glossary. The data in (table 4) has been sorted as per 3 trials for both approaches (industry standard- 1) and (IMI- 2). The mistakes statistics represent occurred over the period of one whole trial in which 100 total items were tagged.

A t-test was done for time and accuracy statistics which provide conclusive support for the hypothesis defined above.

**Table 5.** t- test for both approaches with regards to time for Time and Accuracy for the trials.

| **Source** | **Approach 1** | **Approach 2** | **t** | **p** |
|---|---|---|---|---|
| | M | M | | |
| **Time** | 33.42 | 22.31 | 4.54 | 0.02 |
| **Accuracy** | 16.33 | 5.33 | 4.37 | 0.02 |

Note.*p < .05

So for time component approach 2 yields a lower mean value of 22.31 minutes compared to approach 1 which yielded 33.42 minutes. This makes the IMI approach faster in terms of tagging and tracking inventory. Moreover, the tail value yielded for the time component is (4.54). Since the (0.022) P value is less than the alpha (0.05) therefore we can reject the *null hypothesis 1*. As this helps us confirm the margin of error for our assumptions is under 5% which means we can accept *alternative*

*hypotheses 1* which was -*There is a difference between the mean number of man-hours in the completion of the tagging and tracking tasks performed by experienced professionals and IMI.*

Time component approach 2 yields a lower mean accuracy value of 16 mistakes compared to approach 1 which yielded a mean value of 5 mistakes. The data reveals that the IMI approach is less prone to errors occurring in the tagging and tracking process. Moreover, the tail value yielded from the accuracy component is (4.37). Since we can see that the (0.024)P value is lower than the Alpha value (0.05) we can reject the *null hypothesis 2*. As this helps us confirm the margin of error for our assumptions is under 5% which means we can accept *alternative hypotheses 2* which was - *There is a difference between the mean accuracy in the completion of the tagging and tracking tasks performed by experienced professionals and IMI.* This is because there is also a huge difference in mean accuracy (16.33 for industry standard and 5.33 for IMI approach) of both approaches.

**Implications**

The study reveals that for tagging and tracking inventory Approach 2 which involves the use of IMI is significantly faster and more accurate than approach one. This is made clear by the statistical difference in the mean time for approach one 21.72 minutes is higher than mean time for approach two 12.58 minutes for tagging and tracking 10 inventory items. Infact, the mean difference between the two approaches grew as showcased by graph in figure 4 which showcases approach 2 is increasingly less time consuming as the number of inventory items to tag and track is increased. Furthermore, Approach 2 also maintained better overall accuracy throughout the test as mean accuracy for approach one was 16.33 while mean accuracy for approach 2 was 5.33 for tagging and tracking 10 inventory items and the difference is maintained as inventory is increased (20,30,40,..).

The findings showcase the extent of technological advancement simple mechanisation can have on the tagging and tracking process of tagging and tracking inventory. Moreover, the study's design accurately depicts the real life circumstances, therefore, these results can be extended to the real world application as well. It can be assumed that the findings and the competitive advantage will hold true when IMI is integrated into the daily operations of such retail sector business.

Extensibility for the future. The results in this study account for the difference in terms of time saved. Such findings can be used to calculate cost curves for firms and find the difference in economic profit which results from the use of softwares like IMI. Moreover, the success of softwares like IMI can signal to the market that

this sector is ripe for improvements and technological development. In fact, standardizing the process by using technology can allow for additional economies of scale in the retail popup space.More research can also be conducted on softwares like IMI when they become more widely adopted by firms in India.

**Limitations:**

There are some limitations to this study, statically IMI proves to be a great addition to the process. However, firms in real life may run into diseconomies of scale due to miscommunication that may occur. This may happen as initially employees may not be accumtiomes to a digital process. If employees of a firm are not trained properly the IMI in that scenario may become a problem instead of a solution. In addition, the use of IMI requires components like printers. The control did not account for the time to set up a printer or a tagging gun this may result in additional time for businesses. Moreover, sometimes in real life equipment fails e.g printer jam would leave a business stranded as they wont be able to tag their inventory. Furthermore, human scope for human error is limited but it still exists. As the tags have to be placed by humans, mistakes in tagging could cost time to identify and fix.

**Conclusion:**

The aim of this research is to evaluate the effectiveness of self formulated inventory management software called (IMI) inventory management intelligence in reducing man hours and errors that occur in the process of tagging and tracking inventory received from suppliers. Through the results showcased above we can safely reject all null hypotheses. As it is clear that there is a major difference in the results if businesses add technology like IMI to their processes.

**Acknowledgements:**

I thank my mentors for teaching, assisting, supervising, and guiding me.

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**APPENDIX**

**GLOSSARY**

**Definition:** IMI- It refers to Inventory management Intelligence software, which will be a tool whose effectiveness we are trying to measure in the head to head comparison described above.

**Definition:** Man hours/Time- it refers to the 'time' which the (labour resource) takes to complete a specialised task in an organization's business activity.

**Definition:** Error - in this study refers to any action which results in inefficiency in the tagging and tracking process of a retail business organisation.

**Definition:** Accuracy- refers to the statistic that in this paper will measure the total number of errors that occur in any approach during the tagging and tracking process.

$$Accuracy = \sum_{ti}^{tf} error(occurs\ during\ this\ process)$$

*Where ( $ti$ ) refers to the start time of the tagging and tracking process in the control environment, which will always be 0 seconds.*
*AND*
*Where ( $tf$ ) refers to the finish time of the tagging and tracking process in the control environment, which we will measure.*

**Definition:** tagging and tracking process is the formal classification of a specific format of inventory management employed by small scale retail business that operates using an exhibition or 'pop-up' model to reach its customers.

**Definition:** A primary key refers to a field in the database which is always unique to the attributes of each item. This can be used to identify each inventory item that the business holds. Example from database sample below (ID and VARIATION) combined is the primary key to this sample database. The unique alphanumeric code 1A, 2A, and 2B uniquely identify each item and its attributes like (DESCRIPTION, CATEGORY, PRICE, ORDERLEVEL, AND REORDERLEVEL).

**Definition:** alphanumeric code refers to a combination of alphabets and numbers which is always unique and can be assigned to inventory items in the tagging and tracking process. Example (1A, 2A, and 2B) is a unique alphanumeric code in the sample database shown above.

**Definition:** Tag - it is typically a physical label attached to an item in this case inventory (clothing items, accessories, footwear, etc) in the fashion industry. A tag must contain a unique identification field which corresponds to a database which will be used to ‘track’ it. A sample is shown below.

**Definition:** roll out- it refers to the implementation of a computer system or a software to the end user of that product which could be a business organisation or individuals. This terminology is used in the technological product marketspace.

**Definition:** Control environment- it refers to a set up, where a trial run can be hosted, where the conditions are purposefully altered to simulate real life conditions.

**Defenion:** trial run- refers to the process of subjecting an approach (defined in chapter 2.1) through various tests where performance factors can be measured.

**Definition:** Tools- it refers to all the required material which is used in the process of tagging and tracking: Printer, empty tags, tagging gun, paper, pencils.