IMPACTS OF UNFORESEEN DISRUPTIONS ON DIFFERENT COMPANY- Hàng nguồn

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ABSTRACT

Most South African companies invest largely on research aimed at developing and delivering products on-time. On-time delivery is amongst the many factors of business success. These factors are driven by the effectiveness of Supply Chain Systems. In this paper, it is shown how random disruptions affect the productivity of different company-layouts using systematic random sampling method and theory of probability.

The study reveals that leading sources of disruptions vary from industry to industry. For example, in manufacturing industry machine breakdowns, raw material shortages and employee absenteeism are the frequent causes of disruptions. In fixed-position layouts, retail and wholesale, IT and communications; adverse weather, transport networks and lack of storage facilities are the most common causes of disruption.

It is shown that disruption of one type may not greatly affect productivity of a certain company layout, whilst similar disruption can have devastating effect on another type. It is also shown that there is approximately 5% loss of productivity when order changes are being performed prior to production commencement and that productivity loss also increases exponentially as time progresses. However, it is possible to perform many order changes without any loss of efficiency. It can be concluded that the key variable affecting productivity following random disruption is the time of the change.

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1 INTRODUCTION

Amongst all factors that influence customer’s desire to remain loyal to a manufacturer or job floor, the greatest of all is consistent on-time delivery. Throughout the supply chain, on-time-delivery is crucial for the continuation of the manufacturing effort: should one domino go down, systems’ productivities are likely to suffer. However, in this era it is not sufficient to only know that companies are on time. It is also crucial to know how much they are on time, e.g. supplier performance has never been more important to manufacturing success than it is today. Many researchers identified production scheduling as an effective tool to address on-time delivery. Although the first studies on scheduling started to appear in the early 1900 (Gantt, [1]), the work of Henry Gantt introduced some formal methods into manufacturing operations. Scheduling is about making the most of a limited amount of time. It is defined by Baker [2] as the allocation of resources over time to perform a collection of tasks. It usually tells shop floor personnel when things are supposed to happen. It shows the timing of certain activities and answers questions such as; “If all goes as planned, when will a particular event take place?”

Because time estimates are incorrect and unexpected events do occur, precisely following a planned schedule becomes more difficult as time progresses. In some cases, the system may follow the sequence that the schedule specifies even though planned start and end times are no longer feasible. It is important to point out that as times goes by, the original schedule becomes obsolete and rescheduling actions is needed to address new situations (Viera et al., [3]). Rescheduling is done occasionally in response to disruptions. It is defined as a process of modifying an existing production schedule in response to disruptions (Viera et al., [3]). Viera et al., [3] classify rescheduling environments into two main groups, namely; static and dynamic environments. In a static environment, there is finite set of jobs to be scheduled, whereas in dynamic environment disruption factors such as; machine breakdowns, rush orders, raw materials shortage, quality problems, processing time delays, etc., do occur.

Another gap in the scheduling literature is represented by reflecting the economic performance of the production rescheduling system. It is not quantitatively apparent as to how these random disruptions affect South African economy at large. These random disruptions are directly proportional to the ‘production costs’ and to the frequent schedule changes. Introducing frequent schedule changes certainly gives rise to additional costs, like setup costs, material handling costs, storage costs, penalties as a results of late deliveries, etc. Theory of probability and random systematic sampling method are employed to determine systems’ economic performances?

From an Industrial Engineering perspective, impact of disruptions is perceived to be directly proportional to the probability of failure. Thus, the theory of probability is also used to address impacts of random disruptions for different company layouts. To understand impacts of random disruptions, reliability of the system is determined which gives the probability of failure (i.e., $R = 1 - F$). In this paper, reliability is expressed in terms of time, and is defined as the probability that a system will operate undisrupted for a given period of time. Probability of failure can be given as the frequency with which a system fails. Unreliable systems are not only major source of frustrations; they are also expensive to a company. With today's large-scale systems, failures are quickly becoming the norm rather than the exception.

Finally, this paper considers various “company-layouts or planning departments” and analyzes the impacts these disruption factors have on them. The types of planning departments considered are as follows: 1) production line, 2) fixed material location, 3) product family, and 4) process department (for more see Tompkins et al., [5]). Tompkins et al., [5] defines the above planning departments as follows:
• Production line: made up of machines in series working on the same raw material
• Process department: resources performing similar function are grouped together
• Product family: machines processing similar raw materials are grouped together
• Fixed position layout: production resources are brought to the products

In view of the aforementioned considerations, the main objective of this work is to study the impacts of disruptions under different company layouts using random sampling method, theory of probabilities, and to determine monetary implication of various disruptive factors.

2 MOTIVATIONS

Failure for SA Manufacturing sectors to deliver consistent and reliable service to customers results in significant loss in market share. The success of manufacturing industry at large is greatly dependent on the ability to deliver reliable services to the customers on time, i.e. due to the nature of new businesses, nowadays manufacturing industries need to meet delivery dates. According to a market survey, a 1% improvement in the reliability of goods delivery time could yield up to as much as 5% increase of sale revenue in other markets, [4]. These statistics shows that SA is blindly and massively affected by random disruptions. To-date, in production rescheduling literature, there are no records to suggest aggregate monetary implication following disruption factors. Thus, it is logical to suggest that national economic implication of disruptions is unknown.

Most researchers and manufacturers considered static problems, assuming there will be no disruptions during the process. However, in practice, random disruptions do occur in the system. The inclusion of disruptions in the schedule makes the problems more practical. Random disruptions are unwanted in the production environment as they move the planned optimal process away from its optimum settings. Some companies rely purely on Enterprise Resource Planning (ERP) systems. It is a well known fact that ERP systems do not have sufficient capabilities to provide detailed scheduling and rescheduling solutions for dynamic production systems in the presence of disruptions. ERP systems solutions are effective and only limited to static situations where all parameters are known with certainty. These emphasize the importance of working with non-deterministic situations, or systems that are subject to random variables.

The total SA turnover of all industries for 2009 was estimated at R5,7 trillion, an increment of about 16% compared with the revised estimate for 2008 (R4,9 trillion): key findings by Stats SA [6]. All nine industries considered in the study by Stats SA [6] reflected an increase in turnover between 2008 and 2009. The largest percentage increase of 22,8% was reported by manufacturing industries, followed by electricity, gas and water supply at 21,2%, construction at 17,1%, mining industry at 15,6%, etc. The importance of investigating and analyzing more on the manufacturing industries is accentuated by its contribution to the national gross domestic product, which is currently standing at about 23%, Stats SA [6]. It is interesting to unearth how various disruptions affect these numbers.

The aforementioned limitations or shortcomings indicate that companies of different layout may be affected differently by different investment on resources or contribute differently to the GDP. This partly serves as a drive for SA industries to investigate more on the dynamics of different company layouts. The starting point of process improvements, from Industrial Engineering perspective, is to understand how random disruptions affect various company layouts.

3 LITERATURE SURVEY
As discussed previously, a great deal of effort has been spent in generating optimal production schedules. Herrmann et al., [7] and Pinedo [8] present a comprehensive reference guide for defining and classifying “static” scheduling problems. On the other hand, there is no standard classification scheme for dynamic and stochastic rescheduling problems, i.e., static scheduling problems have been highly explored and little has been said about dynamic scheduling problems. Below is a concise explanation of disruptions classifications, existing literature and concluding remarks on the current literature.

3.1 Disruptions Classification

Due to random disruptions, the actual performance of almost all manufacturing companies often differs from that predicted by the original schedule. Most of these ‘deviations’ are negative, as they affect system performance leading to escalating production costs. These unforeseen disruptions can be classified into two categories (Stoop and Wiers, [9]; Vieira et al., [10]), namely; Capacity disruptions (i.e., disruptions related to manufacturing resources), and Order disruptions (i.e., disruptions related to a job).

When disruptions occur on the manufacturing system, rescheduling has to be triggered and employed to reduce the impact. Typical disruptions that are frequently encountered in manufacturing facilities are, amongst others: machine breakdowns, rush orders, or hot jobs, order cancellations, priority and due date changes, employee unavailability due to various reasons (i.e. strikes, sick leave, etc), raw materials shortages, part damages, unavailability of transportation, variation of process times, variation of set-up times, etc.

3.2 Scheduling in dynamic environment

In dynamic scheduling environment, there are \( n \) jobs that have to be processed on \( m \) machines. Allahverdi [11] considers a two-machine flow-shop scheduling problem with random breakdowns with an objective of minimizing the maximum lateness. Allahverdi demonstrates that if breakdowns occur only in the first machine, the longest processing time (LPT) policy obtains the best results and when they occur only in the second, the best policy is the shortest processing time (SPT). Akturk and Gorgulu [12] suggest a strategy by which after machine failures, part of the initial schedule is rescheduled to match up with the pre-planned schedule at some point in time.

3.3 Existing literature conclusion

Many researchers consider the common problem of rescheduling mainly in response to machine breakdown and ignore (or close eyes to) other types of disruption. Disruptions considered by the great majority in the current literature are principally machine breakdowns (Baker [2], Vieira et al., [3], Herrmann et al., [7], Pinedo [8] and Vieira et al., [10]) in production line department. The only company layout studied vastly in the literature is the ‘production line’. Most of the papers study the negative effects of only this type of disruption (i.e., machine breakdown) on the system performance, which deviates from realistic situations in which production systems may be affected by several types of random disruptions simultaneously. This is an exception to a study by the current Authors, [4] where all potential candidates of disruptions are unified for an aggregate solution of the rescheduling problems.

4 METHODOLOGY

From an Industrial Engineering point of view, disruption is a clear indication of a system failure, e.g., damaged part, a system stopped its operations, machines are idle, etc. System failure has direct relationship with reliability which affects its productivity.
4.1. Reliability and Failure as a quality measure

One of the best ways of determining impacts of disruptions is through reliability. The probability of failure is expressed as a function of time. The expressions under this and the following sections are borrowed from the work of Groover [15]. The relationship between reliability and failure is given as:

\[ R(t) = 1 - \lambda = e^{-\lambda t} \]  

(1)

Where:
- \( \lambda \) is the system failure rate
- \( R(t) \) is the reliability function, can also be given as \( R \)

By considering a “series system or components in series”, reliability is given as:

\[ R_s = R_1 R_2 R_3 ... R_n = (e^{-\lambda_1 t})(e^{-\lambda_2 t})(e^{-\lambda_3 t})...(e^{-\lambda_n t}) = e^{-\sum_{i=1}^{n} \lambda_i t} \]  

(2)

Where \( R_s = e^{-\lambda t} \). From expressions (1) and (2) above, it follows that the overall failure also known as \( F \) is given by:

\[ \lambda = F = \sum_{i=1}^{n} \lambda_i \]  

(3)

Thus, for a system containing \( n \) independent components in series, the system failure rate becomes the sum of the individual components or system failures.

By considering a “parallel system or components in parallel”, reliability is given as:

\[ R_p = 1 - (1 - R_1)(1 - R_2)(1 - R_3)...(1 - R_n) \]  

(4)

From expression (1) and (4) it follows that the system failure is given by:

\[ \lambda = F = 1 - \pi \left(1 - \lambda_k\right) \]  

(5)

There are company layouts that consist of machines or components that are both in series and in parallel. For the unification of the above scenarios, ‘disruption indices’ or weights per scheduling horizon period are introduced. The expression that can be used for this scenario where both series and parallel components operate in a single company layout is given by:

\[ R = w_s R_s \cup w_p R_p \]  

(6)

Where:
- \( w_s \) represents weight for series configuration
- \( w_p \) represents weight for parallel configuration

Since the impact of disruptions can be measured by the productivity, multifactor productivity can be expressed as below:

\[ P_i = \frac{O}{I} = \frac{O}{T} \]  

(7)
Where:

\[ P_i \] represents multifactor productivity
\[ O \] is the output function
\[ I \) or \( T \) is the multifactor input

Considering expression (7) and the fact that reliability or failure rate is given as function of time, productivity can be defined that the time that it takes to produce one unit. Disruption effect a change in production time as given by:

\[ T_p = T_c + FT_d \] (8)

Where:

- \( T_p \) is the practical productive time
- \( T_c \) is the ideal cycle time
- \( F \) is the probability of failure
- \( T_d \) is the average down time

The following sections deals with applications of expressions (1) to (8) on different company layouts.

5 APPLICATION

Some of the leading disruption factors that affect different company layout are listed in Table 1 below.

### Table 1: Various disruptive factors per company layouts

<table>
<thead>
<tr>
<th>Company Layout</th>
<th>Characteristics</th>
<th>Leading Disruptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production-Line</td>
<td>Made up of machines in series working on the same raw material</td>
<td>Machine Breakdowns</td>
</tr>
<tr>
<td>Department</td>
<td></td>
<td>Material Shortage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Employee Absenteeism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Part Damages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Order Changes</td>
</tr>
<tr>
<td>Product Family</td>
<td>Machines processing similar products are grouped together</td>
<td>Machine Breakdowns</td>
</tr>
<tr>
<td>Layout</td>
<td></td>
<td>Material Shortage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage Facility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Employee Absenteeism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Part Damages</td>
</tr>
<tr>
<td>Process Department</td>
<td>Resources performing similar function are grouped together</td>
<td>IT Outages</td>
</tr>
<tr>
<td>Layout</td>
<td></td>
<td>Adverse Weather</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machine Breakdowns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shift Changeovers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Part Damages</td>
</tr>
<tr>
<td>Fixed-position Layout</td>
<td>Resources and materials are brought to the production of the product</td>
<td>Adverse Weather</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Order Changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transportation Networks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage Facility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machine Breakdowns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Part Damages</td>
</tr>
</tbody>
</table>

Since disruption can be considered as failures and also considering the fact that a disruption of one type can cause a disruption of one type to occur (disruption in series) or disruptions can be independent (disruptions in parallel), the knowledge gained under section 4.1 has been applied without loss of generality.
5.1 Product Layout Departments

5.1.1 Production Line Department

Classical production flow-line production considered herein is that of a series configuration set-up. The reliability or failure rate of such a layout has already been presented in expression (2) or (3) above. For the sake of clarity this expressions are repeated here. Expression (3) is that of the traditional upper bound approach where after failure occurrence the part is damaged and is therefore removed from the production line.

For the lower bound approach, when failure occurs parts are not damaged and as such would continue down the production line. When this is the case, the overall failure rate is given by expression similar to that of machines in parallel, or expression (5).

5.1.2 Product Family Layout

In this layout, machines and/or resources are configured in either series or parallel or the union of both. With the union of both configurations expression (6) is applicable. Expression (3) and (4) are applicable for series and parallel layout respectively.

5.1.3 Process department

In this layout resources performing similar functions are grouped together. Thus it can be assumed that the effective machines arrangement is in parallel. The assumption is due to the fact that the effective reliability of a series of machines can be obtained and can be called the reliability of that line (or that machine). Thus a reliability of a process line is given by first employing expression (2) for individual lines and then aggregating by employing expression (4).

5.1.4 Fixed Position Layout

In this layout resources are brought to the product that is being processed. It can be viewed that there is only one workstation available. Thus expression (1) applies.

5.2 Results

Random sampling method and simulation model run reveals in table 2. For the scientific analysis, data was collected from several companies grouped by their similarities in company layouts (i.e., similarities in terms of the products they produce) and the average failure rate was obtained for each type of disruption factor. The averaging is due to the fact that different companies producing similar type of products may have machines of different ages and as such their reliabilities will vary.

It can be seen from the table below how different disruptions affect the system’s performance per company layout. For the sake of comparison the results were presented graphically as given in Figure 1.

<table>
<thead>
<tr>
<th>Leading Disruptions per Company Layout</th>
<th>Failure Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Breakdowns</td>
<td>0.187</td>
</tr>
<tr>
<td>Material Shortage</td>
<td>0.092</td>
</tr>
<tr>
<td>Employee Absenteeism</td>
<td>0.091</td>
</tr>
<tr>
<td>Part Damages</td>
<td>0.075</td>
</tr>
<tr>
<td>Order Changes</td>
<td>0.049</td>
</tr>
</tbody>
</table>

Table 2: Company Layout Disruption Indices
### Process Department

<table>
<thead>
<tr>
<th>Category</th>
<th>Parameter</th>
<th>Impact</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT Outages</td>
<td>(\lambda_1)</td>
<td>Adverse weather</td>
<td>0.193</td>
</tr>
<tr>
<td></td>
<td>(\lambda_2)</td>
<td>Machine Breakdowns</td>
<td>0.129</td>
</tr>
<tr>
<td></td>
<td>(\lambda_3)</td>
<td>Adverse weather</td>
<td>0.076</td>
</tr>
<tr>
<td></td>
<td>(\lambda_4)</td>
<td>Part Damages</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td>(\lambda_5)</td>
<td>Order Changes</td>
<td>0.152</td>
</tr>
</tbody>
</table>

### Product Family

<table>
<thead>
<tr>
<th>Category</th>
<th>Parameter</th>
<th>Impact</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Breakdowns</td>
<td>(\lambda_1)</td>
<td>Machine Breakdowns</td>
<td>0.109</td>
</tr>
<tr>
<td>Material Shortage</td>
<td>(\lambda_2)</td>
<td>Material Shortage</td>
<td>0.003</td>
</tr>
<tr>
<td>Employee Absenteeism</td>
<td>(\lambda_3)</td>
<td>Employee Absenteeism</td>
<td>0.009</td>
</tr>
<tr>
<td>Part Damages</td>
<td>(\lambda_4)</td>
<td>Part Damages</td>
<td>0.028</td>
</tr>
<tr>
<td>Order Changes</td>
<td>(\lambda_5)</td>
<td>Order Changes</td>
<td>0.076</td>
</tr>
</tbody>
</table>

### Fixed-position

<table>
<thead>
<tr>
<th>Category</th>
<th>Parameter</th>
<th>Impact</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adverse weather</td>
<td>(\lambda_1)</td>
<td>Adverse weather</td>
<td>0.176</td>
</tr>
<tr>
<td>Order Changes</td>
<td>(\lambda_2)</td>
<td>Order Changes</td>
<td>0.101</td>
</tr>
<tr>
<td>Transport Networks</td>
<td>(\lambda_3)</td>
<td>Transport Networks</td>
<td>0.271</td>
</tr>
<tr>
<td>Storage Facilities</td>
<td>(\lambda_4)</td>
<td>Storage Facilities</td>
<td>0.419</td>
</tr>
<tr>
<td>Machine Breakdowns</td>
<td>(\lambda_5)</td>
<td>Machine Breakdowns</td>
<td>0.001</td>
</tr>
</tbody>
</table>

### Grand Total

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-position</td>
<td>2.302</td>
</tr>
</tbody>
</table>

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**Figure 1: Impacts of Disruption per Company Layout**

As used above, parameter \(\lambda\) is given as a failure rate of the system - aggregate results furnished below for production line, process, product family and fixed-position layout respectively: \(\lambda_{PL} = 0.099; \lambda_{PR} = 0.123; \lambda_{PF} = 0.045; and, \lambda_{FP} = 0.194\). Considering the fact that these different types of company layout are all found in RSA and also assuming that the effective RSA GDP is influenced by disruptions from these different company layouts, the following data can be derived. Losses per company-layouts: fixed-position layout recorded a total of 42% followed by process department at 27%, then by production line department at 21% and 10% was recorded for product family layout. Assuming further that these company-
layouts equally share R5.7 trillion SA’s total turnover, then the monetary implications per each company layout are as follows (in tabular form):

<table>
<thead>
<tr>
<th>Production Line</th>
<th>Process Department</th>
<th>Product Family</th>
<th>Fixed Position Layout</th>
</tr>
</thead>
<tbody>
<tr>
<td>R 0.141 trillion</td>
<td>R 0.175 trillion</td>
<td>R 0.064 trillion</td>
<td>R 0.276 trillion</td>
</tr>
</tbody>
</table>

From the respective failure rates results above, approximately **R 0.656 trillion** is lost annually by SA’s economic system due to unforeseen disruptions.

For the duration of sample collection, the results reveals that fixed-position layout suffer more due to disruptions than other company layouts, followed by process department, production line and product family layout as the last one. It can be observed that adverse weather, transport networks and storage facilities are the leading candidates of disruptions on fixed layout. Machines breakdown recorded to have the least impact on disruptions, when compared to the impact it has on other company layouts. It can be seen from figure 1 that disruption of one type (e.g. machine breakdown) may not greatly affect productivity of a certain company layout, whilst similar disruption can have devastating effect on another type.

Machine breakdown, material shortages and employee absenteeism are found to be the most leading disruptions candidates in production line department. Product-family layout is not tied down by material shortages, because if material is finished at a particular workstation, it can be sourced from workstations within the group.

6 CONCLUSIONS AND FUTURE RESEARCH ENDEAVORS

In this work the problem of dynamic situations under different types of company layouts considering various candidates of disruptions are discussed.

6.1 Company Layouts Findings

Production-line department - since workers are cross-trained to run every machine in the plant, employee absenteeism proves not to have a major impact on productivity. Also, since workers are responsible for their cells’ output, more autonomy and job ownership is present which resulted in higher productivity levels.

With process layout, it is proven that lower volume means higher costs per unit. Setups are more frequent, hence higher setup costs. Material handling is slower and more inefficient. The span of supervision is small due to job complexities (routing, setups, etc.), so supervisory costs are higher. Since there are multiple machines available, process layouts are not particularly vulnerable to frequent equipment failures like other company layouts.

Unit cost is low as a result of the high volume in product-family layout. Labor specialization results in reduced training time and cost. A wider span of supervision also reduces labor costs and probable reworks or rejects. There is a high degree of labor and equipment utilization. Unlike other company layouts, raw materials shortage is not a problem with this layout.

For many fixed-position layouts, it is shown that the work area may be crowded so that little storage space is available which causes material handling problems (i.e. forklifts congestion) and difficult coordination. There is high utilization and costs of transportations, with materials far-fetch. Most materials are big and not easy to transport, as thus, only special transports are hired. Machine or resource breakdown are far more costly than in other company layouts. It has been and still continuing to remain ‘slave’ to natural calamities, i.e. severe weather conditions, and others.
6.2 Concluding remarks

It is shown that disruption of one type may not greatly affect productivity of a certain company layout, whilst similar disruptions can have devastating effect on another type. It is also shown that there is approximately 5% loss of productivity when order changes are being performed, although it is possible to perform many changes without any loss of efficiency. It can be concluded that the key variable affecting productivity following random disruption is the time of the change.

Escalated manufacturing costs following random disruptions are not dependent on the rate at which they occur, but by the production stage they occur. The study shows that disruption occurring towards the end of the production cycle is likely to cause complete line stoppages (as a part will be withdrawn from the system) at least as compared to disruption occurring at the beginning of the production process, i.e., the case in machining operations.

We showed scientifically that part damage depends on the degree of the damage, i.e. if a part is damaged to the tip, the entire line stops and a part is replaced. If a part has minor damages such that it can still continue getting processed, the effect of disruption is less than that of part withdrawal.

Order changes on the other hand appears to affect different planning departments differently, i.e. we show that this depends on the 'stage' an order change was requested. Some changes does not affect productivity but only increases inventory levels, whereas some lead to companies wasting capacity by producing unwanted products due to changed orders' specifications.

We further conclude that impacts of disruption are dependent on the company-layouts. The results reveal that an impact disruption due to “severe weather” for example is worse for a fixed company layout than other company layouts. Production or work comes to a standstill until this disruption is addressed; hence the study revealed 42% as the total loss associated with this type of company-layout.

7 ACKNOWLEDGEMENTS

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8 REFERENCES


