INVESTIGATION INTO THE APPLICATION OF THE SYSTEMS-ORIENTATED SUPPLY CHAIN RISK MANAGEMENT MODEL IN MANUFACTURING SMALL AND MEDIUM ENTERPRISES

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ABSTRACT

In 2012 South African Small to Medium Manufacturing Enterprises (SMME’s) contributed between 52% and 57% to the Gross Domestic Product (GDP). Ensuring that these businesses remain in operation is crucial to driving economic growth and stability in the country. SMME’s, however, lack the resources to apply risk management, hence leaving their supply chains vulnerable and their businesses susceptible to failure.

This research paper verifies the applicability of the System-Orientated Supply Chain Risk Management (S-O SCRM) model created by Oehmen et al (2010) as a tool to monitor and mitigate risks for SMME’s. The model was adapted and tested in 3 SMME’s in SA using semi structured interviews and visual sensemaking techniques to collect all relevant data.

Through implementation of the S-O SCRM model several potential risks were identified and suitable mitigation strategies were developed to treat the root cause of these threats. The technique developed can be implemented by the business owner hence proving that this method of analysis is an applicable means to monitor an SMME’s supply chain while not requiring additional resources from the business.

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1 INTRODUCTION

Disruptions in a supply chain can impact a business greatly from direct cost such as labour to indirect costs such as loss in reputation. Many new tools and techniques are being introduced into the market, including: TQM, lean manufacturing and strategic sourcing. As businesses are faced with increasing risks to their supply chain, the understanding of these risks are an integral part of managing them successfully [1].

Although supply chain risk management is a relatively new field most of the research conducted is currently aimed towards supply chains of larger manufacturing companies. This paper focuses on the smaller firms that are equally exposed to supply chain risks such as their larger counterparts. SMME’s not only contribute towards the GDP but also created 61% of the employment opportunities found in the country [2] and therefore SCRM in SMME’S is an integral part to ensuring the long term growth.

The System-Orientated Supply Chain Risk Management(S-O SCRM) model established by Oehmen et al [1] was developed and tested on large enterprises and therefore had to be adapted to make it applicable to SMME’s in SA. All modelling requirements stated by Oehmen et al [1] were addressed to ensure the technique implemented was valid after all changes were implemented.

The following research questions were posed for this research paper:

1. Is the System-Oriented Supply Chain Risk Management model an applicable tool for an SME’s in South Africa to utilise?
2. Will the Systems-Orientated Supply Chain Risk Management model provide a comprehensive assessment of a SMME’S risks?

The paper is structured as follows: a literature review, the research methodology implemented, observations and results established, discussion and a conclusion to complete the paper with recommendations for future work.

2 LITERATURE

Research conducted focussed primarily on the definition of supply chain risk management, SMME’s and the S-O SCRM model used in the study. The information studied is summarised to ensure a greater understanding of topics being analysed.

2.1 Supply Chain Risk Management (SCRM)

A supply chain is the flow between; new product development, marketing, operations, distribution, finance and customer service [3]. The controlling of a supply chain involves managing product, information and financial flows to ultimately increase profits of the business. Supply chain risks can be described as any problem that occurs and causes negative effects in the supply chain and for the company [4]. Although there are several methods available on identifying risks, many do not provide the means in which to develop mitigation strategies - the primary reason for this being that businesses are so diverse that no one business solution will be suitable in another business [5].

Due to globalisation there are now both local drivers that originate at a supply-chain entity or particular market and global drivers that originate supply-chain-wide or globally. This leads to both local and global consequences that would impact either particular or multiple markets. Risks can be categorised in areas as shown in figure 1 which also provides example of where the specified risks are likely to be found. Categorising risks aids in identifying the area under threat and developing a targeted approach to prevent or reduce the risk occurrence by the relevant departments [5].
2.2 SMME’s in South Africa

The South African National Small Business Amendment Act of 2003 and 2004 has classified 5 types of SMME’s that include: survivalist enterprise, micro enterprise, very small enterprise, small enterprise and medium enterprise [6].

The definition of SMME’s as stated in the National Small Business can be seen in table 1.

Table 1: Classification of Manufacturing SMEs in South Africa [6]

<table>
<thead>
<tr>
<th>Sector/Subsector</th>
<th>Size or class</th>
<th>Total full-time employees</th>
<th>Total annual turnover (R million)</th>
<th>Total gross asset value (R million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>Micro</td>
<td>5</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Very Small</td>
<td>20</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>50</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>200</td>
<td>51</td>
<td>19</td>
</tr>
</tbody>
</table>

2.3 The System-Oriented Supply Chain Risk Management Model

The model developed by Oehmen et al (2010) is comprised of two components: the risk structure model and the risk dynamic model. These models are then combined to follow a three phase SCRM integration approach - all of which are described below:

2.3.1 Risk Structure Model

The risk structure is composed of 2 elements: the risk cause system and the risk effect system. In figure 2, detailed headings for each element can be seen as well as the integration between the two systems. The casual system aims to find all potential risks within the company based on the focus company, the supply chain and the environmental factors related to the business. An effect system is then utilised to determine what the impact of the risk will be and which specific company targets will be affected. Not meeting business targets can result in either a loss in potential sales or an increase in the total cost of the business. This ultimately leads to a negative impact on the company’s economic value added (EVA).
2.3.2 Risk Dynamic Model

To complete the risk dynamic model successfully a comprehensive risk structure model must be developed. Final risk states are identified which then undergo a root cause analysis to determine the stages that will lead to the actual risk transpiring. The root cause is performed through a 5 why’s analysis that aims to discover all possible initial causes that will result in the risk occurring. Once all the causes are identified, the risk dynamic model is completed by linking all the spaces between the cause and effect using the risks identified in the risk structure model. By performing this process a deeper understanding of the actual reason behind the risk manifesting is developed and hence a more practical solution can be created.

2.3.3 Supply Chain Risk Management Integration

Similar to the general approach taken in risk management [7] there are 3 phases that are associated with the integration of the model. This 3 phase approach can be seen in figure 5 which outlines the steps and order in which each phase must be executed. This approach is used to complete the SCRM procedure and create mitigation strategies based phase 1 and phase 2.

Figure 2: Oehmen et al.’s Generic Risk Structure Model [1]

Figure 3: Supply Chain Risk Management Integration Model (Phases & Steps)[1]
3 RESEARCH METHODOLOGY

The method utilised to collect data along with the models used to capture all the relevant information will be outlined and validated in this section.

3.1 Research Instruments

These are the tools and techniques that were implemented in research project:

3.1.1 Phase 1: Supply Chain Risk Identification

Risk identification must occur at 3 levels: supply chain risk, focus company risks and environmental factor risks which all form part of the causal system shown in figure 2. Each of these sections utilised a different tool to determine potential risks:

- **Supply Chain Risk - Supply Chain development:**
  - This indicates the visibility that the company has throughout their supply chain.

- **Focus Company Risks - Ishikawa diagram and Porters Five Forces:**
  - The Ishikawa diagram will focus on the internal structure of the company while Porters Five Forces analyses the competition faced by the business.

- **Environmental Factor Risks - P.E.S.T. analysis:**
  - As we are researching SMME’s the PEST analysis provided a comprehensive analysis of all potential environmental risks for these size businesses.

All the above mentioned models are completed during the first meeting and aim to create the risk structure model for the company.

3.1.2 Phase 2: Supply Chain Risk Assessment

In this phase risks need to be ranked, the root cause analysis must be conducted and the risk dynamic model must be completed.

Reputation has been added as a target objective in the risk effect system (figure 2). According to Slack and Lewis, [8] reputation forms part of the operations strategy matrix that is utilised to evaluate the business performance objectives. The addition of reputation as a target increases the applicability of the model to businesses as reputation is viewed as a critical factor to number of sales.

As the model is implemented at SMME’s in SA, to simplify the risk effect system and make it accessible to the business owners, all target objectives of the business will directly affect the profit of the business. This eliminates the lost sales, total costs and focus company EVA by replacing it with a simpler profit objective.

When ranking the risks, formula 1 utilised:

\[
\text{Final Risk Value} = \sum_{i=1}^{j} (\text{effect}_i \times \text{impact}_i)
\]

Where: \( j \) = number of nodes entering the risk

Each target objective is assigned a value that relates to the impact that this objective will have on the profit of the business. The sum of all the impact values must be equivalent to 1. Each risk is awarded a probability based on the effect it has on the target objective it is linked to. All values leaving the target objective nodes must also have a sum value equal to 1. All risks that are awarded a final risk value greater than or equal to 0.1 will undergo the root-cause analysis. Any value below 0.1 is not viewed as a threat to the business and therefore does not require further analysis.
The risk dynamic model outlined in section 2.3.2 must then be conducted for the company as it forms part of the risk assessment phase. This consists mainly of a 5 why’s analysis.

A second meeting will be required to complete this phase. All final state risks need to be identified and linked to the relevant target objectives as well as potential root causes must be brainstormed before the meeting takes place to ensure that the dynamic model can be completed efficiently.

### 3.1.3 Phase 3: Supply Chain Risk Mitigation

Through the root cause analysis an understanding for the risks and how they can occur is developed. This will now allow the business to establish mitigation strategies that will target the core problem and not provide a short term “quick fix” that targets one of the risks rather than all the risks that resulted in the problem.

This phase occurs during the second meeting and all potential solutions are discussed in terms of the dynamic model to ensure that all risks along the risk path established are tackled by the solution. Possible mitigation concepts should be identified before the interview to assist in stimulating the procedure and ensure that there are no road blocks or dead ends during the process.

### 3.2 Data Collection Procedure

As SMME’s are constrained by limited staff resources, a workshop would not be feasible and hence a semi-structured interview procedure is utilised to collect the data required. The research tools mentioned in section 3.1 provided the structure and controlled the flow of the interview, however, it is not limited by these models and the interviewee is given the freedom to share any relevant information.

To help increase the interviewee’s understanding of the research being done, a visual sensemaking approach will be applied during the interview. To achieve this technique the cycle in figure 6 will need to be replicated.

![Visual Sensemaking Cycle](image)

**Figure 4: Visual Sensemaking Cycle [9]**

The above cycle was replicated by:

- Having a completed model for each of the research tools (heading, sub headings and examples) - this gives the interviewee an idea of what is required in each field in terms of their own businesses
- A sheet consisting of blank models is completed while the interview is conducted, as information is received it is placed under the relevant headings - this reduces
repetition and allows the owner to understand how the information given is being translated.

4 OBSERVATIONS AND RESULTS
This section will provide company details along with the risk dynamic models created and some of the mitigation strategies developed through the process.

4.1 Company Profiles
A summary of all the companies used for this research study is given in table 2.

Table 2: Company Summary

<table>
<thead>
<tr>
<th>Company</th>
<th>Business Outputs</th>
<th>Interviewee</th>
<th>SMME Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Bolts, screws, rivets and washers</td>
<td>Co-Owner</td>
<td>Small</td>
</tr>
<tr>
<td>B</td>
<td>Precision metal pressed parts, tool making, bending, welding fabrication and general manufacturing (all industries)</td>
<td>Operations Manager</td>
<td>Medium</td>
</tr>
<tr>
<td>C</td>
<td>Designs, manufactures (fabricates) and distributes wrought iron garden furniture</td>
<td>Owner</td>
<td>Small</td>
</tr>
</tbody>
</table>

4.2 Final Models Developed
Through the 2 meetings conducted at the business the completed models found in figures 5 to 7 were developed.

All the risks established for each company are displayed in the figure accompanied by the values awarded for the impacts, effects and the final risk value calculated. From the figure it can be seen that only risks that had final risk values greater than or equal to 0.1 were subject to the risk dynamic process.
Inaccurate Forecasting (0.48)
One Stainless Steel Supplier (0.1)
Imports (0.1)
Brand Identity (0.04)
Inability To Expand (0.15)
Time/Resource Wastage (0.01)
Safety (0.06)

Operational Costs (0.1)
Investment Costs (0.05)
Quality (0.2)
Flexibility (0.2)
Reliability (0.1)
Lead Time (0.05)
Reputation (0.1)
Dependability (0.2)

Figure 5: Final Risk Dynamic Models - Company A
The customer does not have the money
The customer does not have the money
Company A’s customer has not received the money from their customer
The customer does not have the money

Company deals with customers based on relationship - difficult to demand money
Company A’s customer has not received the money from their customer
The customer does not have the money

Material and labour cost are low - better technology
The exchange rate is low
Goods are cheaper to import
Buying in bulk

Unaware that this could affect the business procedure
Management has not set targets/goals for employees
There are no progress markers

Provides cheap labour
The employees are “off the street”
No formal education or resources to learn form

Effect Impact

Figure 6: Final Risk Dynamic Models - Company B
Figure 7: Final Risk Dynamic Models - Company C
4.3 Mitigation Strategies

Once the dynamic models were developed, mitigation strategies could be developed. One mitigation strategy for each company will be outlined in this section to provide an example of how the dynamic analysis contributed to creating a strategy that would target the root cause.

4.3.1 Company A
Risk: Inaccurate Forecasting

Due to the instability in the market, demand for goods fluctuates regularly, making forecasting challenging. The lead time for receiving the raw materials is much longer for imported goods, making forecasting important as shortages will result in profit losses. Raw materials for production need to be constantly available to ensure that the business is able to satisfy their customer’s needs consistently.

To ensure that forecasting is done correctly there needs to be proper inventory monitoring and management. Calculations can also be done to calculate the point of reorder to ensure that material is purchased in time to maintain the correct buffer levels of stock. If the company has the finances there are software packages that can be purchased to perform all the calculations, however as it is an SMME capital expenditure, it is not viable. A more realistic approach will be to monitor their purchasing history and do the calculations manually first to test if placing more emphasis on good inventory control will ensure better forecasting and therefore less sales losses.

4.3.2 Company B
Risk: Employees Lack Health Awareness

In order to keep production costs low, the business hires workers that do not have any formal education and then train them to perform the work required. This training however does not extend to teaching them basic health and hygiene that they have not received through the schooling system. As the business operates in such a confined area there is a large risk that all employees can be affected by a disease at the same time, hence crippling production.

The business needs to ensure that all employees are aware of health and hygiene so that contagious diseases do not spread. This will also aid in increasing the life expectancy of the staff ensuring that the staff lead better lifestyles and are able to work more effectively.

To do this the company should arrange a day in which the workers receive a lecture/talk on health and hygiene. If the business is more focused on health they can arrange health days in which the staff undergo tests and check-ups as well as receive all the required medications and instructions on how to combat the disease. For this business the first option lies within budget, however, if the staff respond positively to the talk, health days will be arranged in the future.

4.3.3 Company C
Risk: Importation of Finish Goods

Countries like China and India have the ability to manufacture goods much cheaper than local manufacturers and hence businesses are opting to import goods instead of utilising the local manufacturers. The only area where a local manufacturer can compete is on quality in this industry. Therefore all products need to be of superior quality to persuade customers to purchase local goods over the cheaper imports.
The root cause identified that importers are able to provide cheaper goods due to their use of modern technology making their manufacturing process more efficient. In terms of technology small businesses cannot compete and therefore suggesting that machinery be purchased is not a viable solution.

A more practical approach would also be to take advantage of the cheaper material available by importing. As the material is standard and many companies require the same goods they can import together in bulk. This will mean less capital expenditure required by each business and the amount ordered by the individual businesses will be a reasonable quantity. One obstacle that could prevent this solution from being successful is that greater storage space will be required to accommodate the imported stock. There will also be a need for larger buffer stock levels to account for the longer lead times associated with importation.

4.4 Summary of Observations

Some of the observations made during the interview and interesting results obtained will be discussed in the section.

When conducting the interviews it was noted that no formal evaluation of the supply chain risk management had been conducted by the businesses in the past.

Currently risks were managed on a trial and error basis where only once a problem was created would a solution be generated to overcome the obstacle faced. This shows the lack of knowledge in the field of supply chain risk management. The only reason this method is employed is based on the fact that the companies are unaware that tools are available to analyse potential risks and that this can be done by the company itself.

The visual sensemaking process proved to be a valuable interview technique as it aided in stimulating the generation of possible risks in the business.

This model has been simplified to a point where the interviewee is able to generate their own risks, with the interviewer only required to steer the conversation and extract the required information. Many of the risk conclusions were drawn by the owner through the process. This is only possible due to the example models displayed during the interview that help the owner to understand what is required (visual sensemaking process).

Due to the industries all forming part of the metal fabrication sector many of the risks established were similar.

The main threat to all SMME’s in this sector will be loss of sales to imported goods. The businesses are finding it difficult to compete with Chinese and Indian industries that can produce goods at a cheaper rate.

Forming mitigation strategies to tackle this is challenging as the South African economy cannot compete. SA government should apply stricter importation regulations to encourage businesses to opt for locally manufactured goods over the imported counterparts.

Another similar threat is the lack of brand identity, where a niche market is found branding is important to ensure maximum gain from the market. Both Company A and C have found niche markets, however they have yet to establish a brand identity. One of the limiting factors causing this to occur is that the company is unaware of the benefit that a brand can bring.

All the SMME’s analysed have room for growth but this growth requires capital and businesses will not take the risk of investing due to the instability of the economy. This could mean limiting growth for the entire country as development of SMME’s will result in job creation and hence government should aid and incentivise SMME growth.
5 DISCUSSION

All relevant findings noted will be shared in the discussion.

The changes made to the System-Orientated Supply Chain Risk Management model were done to simplify the model and make it more applicable to small to medium manufacturing enterprises in South Africa. These changes included using both an Ishikawa diagram and Porters Five forces when analysing the focus company, introducing reputation as a business objective in the effect system, simplifying the dynamic model so that all objectives affect only the profit and creating a decision tree rating approach to rank the risks established.

The data collection method utilised visual sensemaking and semi structured interviews. This method was successful as it allowed the interviewee to share all relevant information and not be confined to the questions stated. Completing the diagrams with the interviewee also aided in the flow of the meetings as they were constantly aware of what has been said, thus reducing repetition and utilising the time more effectively.

From the results drawn the modelling method supported all requirements, addressed the network character of supply chain relationship and risks, included risk causes and risk effects, illustrated the dynamic behaviour of the system- i.e. showing possible development paths of risks, supported hierarchical structuring, showed the interrelation of different supply chain risks, supported qualitative data and can consider future quantitative modelling approaches - stated by Oehmen, Ziegenbein, Alard, & Schönsleben (2010) [1].

By implementing the model at the 3 businesses and discovering all potential risks it can be stated that the System-Oriented Supply Chain Risk Management model is applicable for analysis of an SMME’s potential risks. The root cause analysis that was conducted is only feasible if performed with the business- this ensures that the results from the study are a true reflection of what the business experiences. This applies to the mitigation strategies as well. Many theories may sound feasible, however only with the deeper understanding of exactly how the business operates, can we judge whether the solution will work when implemented.

The applicability of the model is limited to the metal fabrication industry as these were the only types of businesses utilised in the study. Due to the homogenous nature of SMME’s it can be extrapolated however, that the model is applicable in all SMME’s. As there is limited information available on SMME’s and their characteristics are similar to the above mentioned statement, it cannot be taken at face value and more research would need to be conducted to fully substantiate this conclusion.

To address the research questions stated in the introduction:

Is the System-Oriented Supply Chain Risk Management model an applicable tool for an SME’s in South Africa to utilise?

By implanting the model in small to medium manufacturing enterprises within SA we were able to determine that the System-Oriented Supply Chain Risk Management model is an applicable tool to implement.

Will the Systems-Orientated Supply Chain Risk Management model provide a comprehensive assessment of a SMME’s risks?

The results generated through the study prove that this technique can effectively discover potential risks facing the business and through the assessment create mitigation strategies to combat these risks effectively.

The research conducted was successful in tackling the questions asked and comprehensive conclusions were drawn regarding the use of the System-Oriented Supply Chain Risk Management model in South Africa.
6 CONCLUSION

- The instruments used to collect data included plotting the supply chain, Porters Five Forces, Ishikawa diagram and a P.E.S.T. analysis.
- The interview technique included semi structured interview and utilised visual sensemaking tools.
- Research was done to make the models more applicable to SMME’s in SA and completed diagrams were established to support the visual sensemaking technique.
- The SO-SCRM model provided accurate results in terms of identifying all major and minor risks in the business.
- The model worked for all businesses that were tested - showing applicability within SMME’s , however due to the limited sample size the validity of this result is compromised.

7 RECOMMENDATIONS FOR FUTURE WORK

- To increase the visual sensemaking aspect for the risk structure model a value stream map of the operation could be plotted and this could be analysed for potential risks in the focus business.
- The model can be tested on businesses that would like to start up as a tool to determine potential risks for the business.
- Determine if the current model and method developed can be implemented by a business owner alone to successfully implement supply chain risk management.

8 ACKNOWLEDGEMENTS

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9 REFERENCES


