Green Production Adoption for Small- and Medium-Sized Enterprises in China: A Case Study

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ABSTRACT:
Eco-friendly and sustainable development is constantly explored and intensely studied in recent years in business sector and academia. Many enterprises are seeking to adopt green production (GP) while researchers are investigating the practice from various perspectives. Although GP has been advocated and implemented in the developed countries for more than two decades, it is still primitive in development in China. Through an in-depth investigation of the GP initiative taken by a small garment manufacturing company in Shanghai, this study explored the drivers for and the barriers to GP adoption from the perspective of the small- and medium-sized enterprises (SMEs) and proposed a model for gradual implementation.

Keywords:
Operations improvement, process innovation, quality management, reverse logistics, supply chain management

1. INTRODUCTION

Green production (GP) has an environmental purpose. The objective is to produce green products that include “technologies and products of both a preventive or a remedial nature for the prevention, reduction, elimination, and treatment of air emissions, waste and wastewater, soil and groundwater contamination, noise and vibration as well as radiation” (European Commission, 2009, p. 32). It can be seen as a response to increasing environmental regulations resulting from enhanced public awareness of environmental conservation and growing demand for green products. Nevertheless, GP could provide opportunities to maximize efficiency of resource utilization and minimize negative environmental impacts during the manufacturing process, thereby benefiting a single firm and ultimately the entire industry in the long run (Emmett & Sood, 2010). This is achieved through cutback in the use of virgin materials and non-renewable energy on top of reduction in emissions, hazards, and effluents. As such, it can be said that legal and regulatory compliance along with economic incentives are the main driving forces for GP.

While there are drivers for large organizations to adopt green practices (Business Pundit, 2009;
Planetsave, 2013), there are also barriers and obstacles to GP implementation which are not easy to overcome particularly for small firms (Walker, Redmond, Sheridan, Wang, & Goeft, 2008; Westervelt, 2014). Among them, high setup cost, lack of technology and infrastructure, and absence of government support are most common (Luthra., Kumar, Kumar, & Haleem, 2011). Lack of knowledge and experience, in addition to the absence of a strong sense of social responsibility, have also caused significant reluctance in taking GP initiatives (Balasubramanian, 2012). These obstacles are particularly prominent in developing countries hence hindering the widespread adoption of GP practices. Take China as an example. Despite its rapid expansion in manufacturing in the last few decades turning itself into the world’s largest manufacturing base, GP adoption there is still in its infancy (Liu et al., 2012). To better understand the situation, this study examined in detail the GP initiative of a small garment manufacturing company in Shanghai to investigate the main driving forces of GP adoption in the Chinese manufacturing industry and identify the major barriers the industry is facing. On the basis of the findings, a model for gradual GP adoption was proposed.

The remainder of this paper will commence with a brief literature review on GP, the drivers for and the obstacles to its implementation. Next, the research methodology will be presented, followed by the findings of the study. Implications of the study findings will then be discussed. The paper will conclude by proposing a model for GP adoption which focuses on close collaboration between the government and the industry as well as gradual implementation to increase the chances of success.

2. LITERATURE REVIEW

2.1 Green Production

GP aims to decrease the adverse environmental impact of the production process at each stage (Emmett & Sood, 2010). It matches supply with demand and optimizes production with waste minimization (Baines, Brown, Benedettini, & Ball, 2012). As a corporation strategy that focuses on profitability by adopting environment friendly manufacturing practices (Seliger, 2007), GP works towards making organizations more responsible for the environment through pollution prevention, product stewardship, efficient outcomes from streamline internal processes, technological innovation as well as waste reduction at every stage of the supply chain (Chan, 2005).
GP is not equivalent to green supply chain management (GSCM) or sustainable supply chain management (SSCM) although there is some overlapping between the different fields. While SSCM refers to “the pursuit of sustainability objectives through the purchasing and supply process, incorporating social, economic and environmental elements” (Walker & Jones, 2012, p. 15), GP focuses more on utilizing environmental friendly materials and advanced technologies in manufacturing to minimize pollution and reduce waste. SSCM includes a wider scope and attempts to strike a balance among social, economic and environmental aspects of the impacts of the business activities so as to make the operation sustainable. GP can be seen as an endeavour to lessen environmental impacts in production while increasing economic gain in the long run. Consideration of social issues is comparatively given a lower priority. Nevertheless, GP can be seen as a major initiative contributing to the success of SSCM.

The extant literature mentions three fundamental purposes of GP: (1) To eliminate or decrease exhaust, disasters, effluents, and accidents (Emmett & Sood, 2010; Prakash, 2000); (2) To reduce life cycle expenditure of products and improve effectiveness of services (Chan, 2005); and (3) To cut the use of raw materials and non-renewable forms of energy, such as coal and petroleum (Testa & Iraldo, 2010). To achieve these three objectives, GP would involve redesigning of conventional manufacturing technology, strategy and structure, in addition to consideration of internal and external drivers and constraints, cultures, safety measures, regulations, as well as environmental impacts (Emmett & Sood, 2010). In short, GP focuses on the principle of 3R – reduce, recycle and reuse. It reduces pollutions and wastes by minimizing resource used, recycles the recyclable portion of the wastes, and reuses the recycled materials for future manufacturing.

2.2 Drivers of Green Production

With increasing public awareness of the environmental impacts of business activities, countries worldwide are making stiffer legislations for environmental protection. At the same time, consumers are gradually focusing not only on the greenness of the products but also that of the production processes (Balasubramanian, 2012). Legal or regulatory compliance is a major driving force for GP adoption. It helps the industry develop GP methodologies and phase out older technologies to meet more stringent environmental regulation requirements and reduce penalty due to non-compliance
Economic drivers refer to lower consumption of raw material and energy resulting in cost reduction. Cost saving also comes from lower medical expenses due to reduced liabilities to employees, consumers, and the public surroundings upon turning green (Emmett & Sood, 2010; Balasubramanian, 2012; Bhool & Narwal, 2013). Savings can also be made in waste management, treatments, and disposal as well as in production over the entire life cycle of products as a result of more efficient green production processes, reduced rework, reduced overall waste, and increased recycling (Emmett & Sood, 2010).

Furthermore, adoption of GP can help organizations enhance their corporate image (Diabat & Govindan, 2011) and boost sales (Balasubramanian, 2012). A green image may also help a firm to stay ahead of its competitors and facilitate expansion to overseas market owing to strong demand for green products (Liu et al., 2012). Therefore, organizations adopting GP could not only avoid penalty for not complying with environmental regulations but also offset the cost through the reaping of tangible and intangible benefits associated with the initiative.

2.3 Obstacles to Green Production

One of the major barriers to GP is the high setup cost. Adoption of new technology and re-engineering production process are often very costly which can be an insurmountable obstacle to many small- and medium-sized firms (Luthra et al., 2011). However, GP can also create a massive cost advantage in terms of increased production efficiency and boosted sales in the medium to long run. Consequently, a possible approach to GP adoption is to take incremental steps by starting off with a small-scale implementation so that GP can pay for itself. Firms can then gradually escalate their commitment to a full GP adoption (Balasubramanian, 2012).

Feeble top management leadership or insufficient organization commitment is also a barrier for many companies to adopt GP practices as it usually takes time for a GP initiative to materialize (Balaji, Velmurugan, & Manikanda Prasath, 2014). Pragmatic organization culture and inadequate awareness of green production could be another impediment since employees are not encouraged to appreciate the importance of environmental-friendly manufacturing practices (Ojo, Mbowa, & Akinlabi, 2014).
Lack of cooperation among supply chain partners can also be a hindrance to GP adoption particularly when each party has its own priorities and perception of GP (Muduli & Barve, 2013). Without the cooperation and collaboration of the supply chain partners, GP will remain fragmentary and a full adoption across the entire supply chain is difficult to achieve.

Others hurdles to GP include lack of knowledge and experience in the practices. Many organizations are not in touch with the latest GP practices and even not totally aware of the carbon footprint of their own supply chains (Balasubramanian, 2012). Inadequate environmental legislations and lack of government support also hinder the adoption of GP by the industry (Luthra et al., 2011).

While GP has been adopted by many large business corporations for reason of fulfilling their corporate social responsibility (Luetkenhorst, 2004), it is still not widely adopted by small- and medium-sized enterprises (SMEs) (Simpson, Taylor, & Barker, 2004). Walker, Redmond, and Giles (2010) contended that poor awareness of collective impacts of small business on the environment, lack of convincing business case for change, lack of appropriate tools for small firms to manage their environmental impacts, and strong resistance of small business owners to change are among the major barriers. Although there are proposed approaches to promoting GP adoption in this regard (see Walker et al., 2010; Calipinar & Ulas, 2013), research on actual GP implementation by SMEs and the difficulties they need to overcome is limited. This study aims at supplementing the inadequacy by investigating in depth a case of GP adoption by a small manufacturing company in China.

3. METHODOLOGY

Case study methodology was used in this research to identify the drivers for and the obstacles to GP adoption by the SMEs in China. To enable a focused in-depth investigation, a single case was selected for study through purposive sampling. Single case study is relevant and useful to address ‘how’ and ‘why’ questions that require an extensive and “in-depth” description of a phenomenon that is not totally well understood (Eisenhardt & Graebner, 2007; Yin 2009). Purposive sampling focuses on samples with characteristics which are most relevant with respect to the research topic (Maoz, 2002; Yin, 2009). Since not many SMEs in China have adopted GP, a relatively small Chinese garment manufacturing firm – Company X – was selected from the list of SMEs with green initiatives
from the National Development and Reform Commission website (www.ndrc.gov.cn) of the Chinese government for investigation. Company X is among the very few small manufacturers in Shanghai – a major industrial city in China – which has adopted GP and is regarded as one of the pioneers in this regard. Being small in size and a first adopter among its peers with a comprehensive adoption campaign, Company X met all the requirements of purposive sampling for this study. The CEO of the company was contacted via e-mail in July 2014 explaining the purpose of the research followed up by courtesy telephone call to solicit participation. In the end, Company X agreed to be interviewed.

Semi-structured interviews were conducted with the senior management of the company to understand the GP implementation process, the drivers for the adoption and the obstacles the company had encountered. Data collection took place in Company X’s head office and its plants from August to October in 2014. Staff members interviewed included top executive officers and senior production managers. Several rounds of interviews were conducted, each of which lasted from 45 to 90 minutes. Guided by the company staff, visits to the plants were made at the end of the interviews to observe onsite the GP practices implemented. To ensure there was no misunderstanding or misinterpretation of the information collected, follow-up clarifications with the interviewees were sought via emails or telephone calls where necessary.

4. FINDINGS

4.1 Company Profile and Overview of GP Adoption

Company X was established in 1998 in Shanghai with only one plant run by eight employees. It had since expanded to three plants with a head office. The company gradually grew in size and by 2014 the plant workforce had increased to 87 workers. Over the years, there was not much change in its production technology despite the growing demand for green products. With financial support from its major overseas customer, Company X adopted GP in recent years which had brought huge success to its business. The company applied strict standards in its green manufacturing process to ensure compliance of environmental regulations of the Chinese government. For machine operators who were not familiar with GP practices, the company offered training to them to transfer knowledge and develop the necessary skills. Upon the GP adoption, all finished products were required to undergo thorough chemical detection test before delivering to clients to ensure quality and regulation
compliance. The company had since enjoyed a progressive gain in annual profit as a result of increasing demand for its green products. Revenue increased at a rate of about 15% each year amounting to around ten million RMB in 2013.

4.2 Before and After GP Adoption

Prior to the GP adoption, Company X used a cost minimization approach in running its supply chain. The focus was on productivity rather than lessening the negative impacts on the environment. First of all, raw materials, regardless of whether they were environment friendly or not, were purchased at the lowest prices to minimize cost. Then, there was little concern about the environment during the production process. Water used in dyeing the fabrics for making the garments, which was rich in chemicals and other toxic pollutants, was emitted into the nearby rivers and lakes without processing. Coal-fired boiler was used for colouring and drying the fabrics which produced carbon dioxide, sulphur dioxide, and other pollutants. The hot gas was emitted to the atmosphere directly without decarbonization or purification. Further, there was no investment in the use of cleaner vehicles, alternative fuel or optimization in routing or scheduling to reduce carbon footprint when delivering finished products to customers.

Upon the introduction of tougher environmental regulations by the Chinese government in recent years, there was pressure for GP adoption. With a 5 million RMB financial assistance from its major overseas customer, Company X replaced all its out-dated machines with more technologically advanced and environment friendly production equipment. The collaboration, which was based on trust built from many years of good buyer-supplier relationship, was considered beneficial to both parties. To the overseas customer, the investment further consolidated Company X’s commitment as its quality and reliable supplier thus minimizing its supply risk. To Company X, the investment enhanced its competitive advantage by making it one of the first adopters of GP in the industry and a quality supplier meeting all the domestic and international environmental regulations.

The GP implementation of Company X actually involved the redesigning of the entire supply chain. First of all, green sourcing was adopted to replace the previous low-cost purchasing. Instead of buying raw materials at lowest prices, only those with eco-mark or green certificate (i.e., environment friendly certification) were used for manufacturing. This helped minimize the harm of the
manufacturing activity done to the environment right from the beginning. Then, two new green practices – green discharging and recycling, which were absent in the past – were introduced in the production process to constitute green manufacturing. The production process comprised, among other activities, colouring, printing, and drying of fabrics. The green discharging process removed the toxic pollutants from the sewage via the newly installed sewage processing facilities before releasing the dyeing water to the rivers. The recycling process classified wastes generated in the production process into recyclable and non-recyclable categories. The recyclable wastes were reused in the production cycle while the non-recyclable wastes were disposed of via third-party logistics (3PL) service provider in eco-friendly manners according to their respective types. With subsidy from the local government, the coal-fired boiler was replaced by one fired by natural gas which produced much less greenhouse gases and other pollutants. At this stage, Company X’s GP initiative has focused mainly on upstream purchasing and midstream production mainly due to limitations in finance and management resources. Downstream distribution with the adoption of green logistics practices has yet to be implemented.

The case of Company X clearly shows that the firm has closely followed the 3R principle of GP, i.e., reduce, recycle and reuse. The green purchasing practice, i.e., using only raw materials with eco-mark or green certificate, was set to minimize emissions, hazards and effluents from source. The green manufacturing practices, i.e., using natural gas fired boiler for colouring and drying fabrics and purifying sewage before discharging, also contribute to reducing emission and pollution. The classification of wastes into recyclable and non-recyclable categories facilitates recycling and reuse which in the end also helps reduce the use of raw materials and decrease negative impacts on the environment. The major investments in equipment in this case include the replacement of the coal-fired boiler with a natural gas fired boiler, the purchase of a detector machine that can determine pH value and formalin contents of fabrics, and the upgrading of the fabric printing machine equipped with sewage disposal function that could purify the sewage by removing toxic sediments. These machines were costly and not easily affordable to many small- and medium-sized manufacturers. In the long run, however, the investment could bring significant tangible benefits to the company thereby justifies the initial cost outlay, not to mention the intangible benefits to the environment. Figure 1 shows the GP adoption of Company X across its entire supply chain comparing the before and after situations.
5. DISCUSSION

In-depth analysis of the case of Company X reveals that the drivers for and the obstacles to GP adoption are similar to those mentioned in the literature.

5.1 Drivers of GP Adoption

The major driver for GP adoption in China at this stage is mandatory compliance with environmental regulations. Under the amended Environmental Protection Law of China which came into effect in 2014 (European Commission, 2014), all companies in China, particularly those in the manufacturing industry, are required to take certain green supply chain management measures to limit the level of pollution so as to protect the environment. Severe penalties in terms of huge fine or forced shutdown of business apply when the laws and regulations are not duly complied with. To enforce the new environmental laws, local governments have increased the frequency of onsite random checks without giving prior notice. Consequently, many manufacturers are forced to invest in GP to various extents in compliance with the law so as to avoid heavy penalty. As the interviewees revealed, regulation compliance is also the major driver for GP adoption in the case of Company X.

GP adoption can also help a firm to establish its green image and increase its popularity among environment conscious customers. Taking Company X as an example, its environmental performance has improved since the adoption of GP. Not only energy consumption has been reduced due to higher efficiency of the new boiler, lesser amount of toxic effluents has been discharged hence reducing the extent of pollution to the environment as well as damage to the eco-system. These endeavours have reflected the company’s commitment to its corporate social responsibility and help build a green company image. Recent sales figures show an upward trend suggesting that the green image endeavour of Company X might have been successful.

5.2 Obstacles to GP Adoption

Obviously, the major obstacle to GP adoption in China at the moment is the huge start-up costs. In the case of Company X, they include the following:
1) **Higher operation cost**

   a) **Equipment upgrade**: In its GP initiative, Company X invested in the procurement of a new fabric printing machine with sewage disposal function, replacement of the coal-fired boiler with and a natural gas boiler, and the installation of a formalin detection machine. All these procurements costed a lot of money which could be prohibitive to many SMEs.

   b) **Additional operating procedures**: GP involves more procedures in the manufacturing process compared with normal production. This may include sewage treatment, exhaust gas decarbonization, testing, and recycling. Take Company X as an example. The GP initiative has added new steps in the manufacturing process such as testing, purifying, categorizing and recycling. These additional procedures have inevitably added to the total operating cost.

2) **Procurement cost**

   Sourcing green raw materials increases the procurement cost due to the fact that raw materials with eco-mark or green certificate are usually higher in price. In the case of Company X, for example, pigments with eco-mark or green certificate used for printing the fabrics are more expensive than normal pigments.

3) **Discharge cost**

   Discharge cost is incurred in controlling the effluent emission to protect the environment from pollution. In the case of Company X, it not only required the company to purchase a fabric printing machine with sewage disposal functional but also special chemicals to dissolve the pollutants in water and precipitate them as sediments for removal prior to discharge.

4) **Recycling cost**

   Categorizing production wastes for recycling and reuse as well as disposal requires professional service and therefore incurs additional costs. In the case of Company X, this function was outsourced to 3PL service provider as it was cheaper and more cost effective than doing it in-house.

5) **Administrative cost**

   Costs are also incurred in closely monitoring the success of GP adoption using appropriate KPIs and provision of adequate training to staff members to promote awareness and enhance skills.
Another obstacle to GP adoption is the lack of appropriate skills and capability of the management to manage the changes. To ensure success, comprehensive organizational management skills are required from the senior managers to (1) oversee GP implementation in a smooth manner, innovate new organizational culture to nurture support and awareness of employees, (2) provide various training to staff to transfer knowledge and skills, and (3) establish new KPIs for monitoring performance. To carry out these activities, the senior managers would need to formulate diverse strategic plans to guide the implementation. Such complexity might decrease the feasibility of implementation if the required management skills and capability are not available. In the case of Company X, the GP adoption had been planned for a year prior to implementation with the involvement of the entire management team. Adequate preparation and an incremental adoption approach have helped the company to minimize the chances of failure in the initiative.

6. A PROPOSED GP ADOPTION MODEL

Using Company X as a reference, which is one of the successful pioneers in GP adoption among the small- and medium-sized manufacturers in the manufacturing industry of China, an adoption model has been proposed (See Figure 2). The model takes into account the prevailing drivers for and the major obstacles to GP adoption as revealed in the case study of Company X and depicts the process in a generic manner. While the actual adoption process and other circumstantial details many vary from case to case, the model represents a general situation.

Table 1 provides the details in each of the steps in the proposed GP adoption model. The roles of the various parties, such as the government, trade associations, participating firms, and supply chain partners, involved in the process are also described.

7. CONCLUSION

Through an in-depth investigation of the GP adoption process of a small garment manufacturing
This study explored the prevailing drivers for and the major barriers to GP adoption in China faced by many SMEs. The findings reveal that legal or regulatory compliance is the major driving force for GP particularly upon the introduction of the new environmental protection laws in 2014 by the Chinese government. While there are other drivers such as better company image and induced demand for green products, penalty avoidance still seems to be the primary reason for implementing GP particularly for small firms at the moment.

For GP barriers, the obvious obstacle is the investment cost for purchasing new manufacturing and testing equipment or setting up pollution abating facilities. This is particularly critical for small- and medium-sized manufacturing firms as they are usually limited in resources which may include finance, GP knowledge, and management capability. While in the short run GP would incur higher cost in operation, it could bring significant benefits to a company through the use of more energy efficient machines and recycled materials and resources. Unit production cost could be reduced which translates to higher profit. GP could also help a firm establish a green company image which could be appealing to environment conscious customers who prefer green products. As a result, customer loyalty could be secured and additional demand could be induced which again would translate to increased revenue.

Based on the findings from the study, a GP adoption model for the Chinese manufacturing industry has been proposed which emphasizes legal legislation and government subsidies as triggers to GP implementation. To ensure success, the model also advocates close collaboration between government and industry as well as among supply chain partners. Incremental implementation is favoured so that teething problems can be ironed out and experience can be accumulated prior to full-scale adoption. With proper planning and gradual implementation, GP might be able to pay for itself which could be a desirable approach to small- and medium-sized manufacturers.

While single case study permits in-depth investigation and documentation of the drivers and the obstacles of GP adoption for SMEs in China, the approach also suffers from inter-related issues of methodological rigour, researcher subjectivity, and external validity. To overcome the limitation, multiple case study design can be adopted in future research so as to apply the replication logic to corroborate and extend findings of the various cases investigated.
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Figure 1: GP Adoption of Company X

| Sourcing       | Before GP Adoption: Use raw materials at lowest cost. |
|               | After GP Adoption: Use raw materials with equipment or green certificate only. |

| Manufacturing  | Before GP Adoption: (1) Use coal fired boiler for heating with noxious gas emission, such as CO2 and SO2, and lower efficiency. (2) No test on final products. |
|               | After GP Adoption: (1) Use natural gas fired boiler for heating with less noxious gas emission and higher efficiency. (2) Test final products for purity and formalin content to ensure meeting of required standards. |

| Discharging    | Before GP Adoption: No treatment of dyeing water before discharging. |
|               | After GP Adoption: Purify sewage by removing chemicals and toxic pollutants from dyeing water before discharging. |

| Recycling      | Before GP Adoption: No recycling of hard wastes generated during the production process. |

| Distribution   | Before GP Adoption: No use of renew vehicles or alternative fuel to reduce carbon emission. |
|               | After GP Adoption: Same as before. Green logistics practices have yet to be implemented. |

Figure 2: A Proposed GP Adoption Model

1. Environmental Laws and Regulations
2. Incentives for GP Adoption
3. Awareness and Knowledge Acquisition
4. Investigation and Planning
   - Investigation of industry practices
   - External resource support
   - Strategic formulation and operation planning
5. GP Adoption
   - Investment in equipment and facilities
   - Monitoring of performance with KPIs
   - Training courses for staff

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Table 1: Activities Involved in GP Adoption

<table>
<thead>
<tr>
<th>Step</th>
<th>Activities involved</th>
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<tbody>
<tr>
<td>(1)</td>
<td>Legal and regulatory compliance is still the primary driving force for GP adoption in China. The new National Environmental Protection Law introduced by the Chinese government provides a solid basis for stringent control and monitoring and of emissions from industrial activities. Heavy fines are imposed for non-compliance. Companies are therefore compelled to follow strictly the governmental rules and standards in order to avoid severe penalty.</td>
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<tr>
<td>(2)</td>
<td>To encourage small manufacturing companies to adopt GP, the Chinese government could provide subsidy to help reduce setup cost, e.g., subsidized boiler replacement in the case of Company X. The government could also subsidize or provide free training courses to workers to promote awareness and enhance skills in GP.</td>
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<td>(3)</td>
<td>The Chinese government could also collaborate with the industry to prepare GP brochures and guidelines for distribution. Trade associations could also organize seminars and workshops to provide training and transfer green knowledge to participating companies.</td>
</tr>
<tr>
<td>(4)</td>
<td>For companies decided to adopt GP, they should investigate the practices of the industry and learn from the peers. Big corporations pioneering in GP could be exemplars for SMEs to follow so as to increase the chances of success. External support could also be sought from supply chain partners to promote GP adoption. In the case of Company X, the external financial support it obtained from its long-term overseas customer played a significant role in the success of the GP initiative. Proper planning for operation and adequate preparation for exceptions could also improve the chances of success of GP adoption. In the case of Company X, the whole process of investigation, planning and preparation took a whole year to complete.</td>
</tr>
<tr>
<td>(5)</td>
<td>To minimize risk of failure due to lack of experience and other unanticipated issues, GP adoption should be implemented incrementally starting from one function or one segment of the supply chain, such as green sourcing. This could help reduce the initial cash outlay, facilitate monitoring of performance, enable seamless transfer of knowledge and skills to employees, and reduce resistance to change. Appropriate KPIs should also be used to monitor performance and to iron out teething problems for continuous improvement. Adequate training to staff should also be provided prior to expanding the scale of GP adoption.</td>
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