INVESTIGATING THE DETERMINANTS FOR SUCCESSFULLY MANAGING NEW TECHNOLOGY IN SMALL AND MEDIUM ENTERPRISES

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ABSTRACT: The paper investigates the determinants for successfully managing new technology in small and medium manufacturing enterprises. Literature suggests that new technology improves business performance, competitiveness, quality and enhances business growth. Determinants that were investigated in this paper included training, communication, leadership, absorptive capacity, research and development and collaboration between these enterprises and institutions of higher learning. Multiple case studies were done on three manufacturing enterprises which acquired new technology over the past two years. An evaluation for the need of new technology and how the process was going to be managed was done through the Force Field methodology. An analysis of these enterprises' business performance established a positive relationship between acquisition of new technology and business performance. The ability of the employees to deliver a quality product, through a sound quality assurance process was found to correlate with business performance. Employee oriented leadership was found to have supported a smooth implementation of the new technology. Inadequate training methods, task oriented leadership and lack of research and development were found to limit the absorptive capacity of these enterprises. Collaboration between these enterprises and technical colleges and universities that offer further Advanced Manufacturing Technology courses was found missing.
KEYWORDS: Determinants, Research and Development, Technology, Force Field Analysis, Absorptive Capacity.

1. INTRODUCTION

Managing new technology include acquiring and using new technology to create competitive advantage, [1]; to improve economic, social and wealth quotient of enterprises, [2]. The need to acquire new technology stems from the dynamics that evolve in a manufacturing set up such as new materials, new products and the need to satisfy ever changing customers' needs, [2], [3]. Technology management employs various concepts that include technology strategy, technology forecasting, technology road mapping, technology project portfolio and technology portfolio, [4]. These concepts require a lot of resources and skill which are not usually found in Small and Medium Enterprises (SMEs), [5]. Some authors, [2], have categorised the process of technology management into eight phases that include:

- Forecasting and Assessment
- Planning and Strategy
- Acquisition and Development
- Transfer
- Adoption and Adaptation
- Diffusion and Substitution
- Utilisation
- Phasing-out

Acquisition and use of new technology by SMEs brings challenges that include staff resistance from fear of losing jobs, hostility from labour unions, [2]; poor sourcing due to lack of resources and scouting, [6], poor identification due to lack of knowledge management, poor or weak absorptive capacity due to lack of skill, [7].

The choice to acquire new technology is influenced by the company's strategy. Strategy is the determination of basic long-term goals including objectives of an the enterprise, the adoption of courses of action and allocation of resources necessary for carrying out these goals Chandler, [8]. Strategy enhances management's focus on linkages between external market requirements and internal organizational and technological resources, capability and competitive advantage, [9]. Enterprise strategies include corporate / business strategy and functional strategies, [2] Business strategy is the common theme or strategic posture at higher levels of the organisational, encompassing all activities in an organisation. Functional strategies include manufacturing strategy, market strategy and Research and Development strategy, [10]. Manufacturing strategy is a pattern of decisions, both structural and infrastructural, which determine the capability of a manufacturing system and specify how it will operate to meet a set of manufacturing objectives which are consistent with overall business objectives, [11], [12], [13].

Acquiring new technology brings about organisational challenges that range from staff resistance to poor absorptive capacity causing the breed of lack of trust between management and staff, [2], [5]. The Force Field methodology is a tool that can be used to manage such changes. Force Field Analysis (FFA), developed by [14], is widely used as a decision making tool in planning and implementing change management programs in organisations, [15]. The FFA is a model based on the idea that forces drive or restrain changes, [14] these forces include availability of resources, organisational structures, relationships, attitudes of people, regulations, personal or group needs, present or past practices, costs, people and institutional policies or norms, [15].

This paper investigates the determinants discusses these forces as faced by SMEs in acquiring and implementing new technology, a research gap identified by, [16] and [17], "of integrating human and organisational aspects with technology investments", and supports the work of, [18] who indicated that in-order to realise full benefits of new technology there is need for a "systematic change in the management of people and machines including planning, plant culture, plant organisation, job design, compensation, selection and training, and labour management relations". The need to manage organisational changes brought about by the introduction of new technology helps to prevent the impacts of failed technology investments,

which include; harm to an organisation's reputation; broken trust between workers and management, reduced management credibility and slower learning curve, [19].

Table 1. Summaries of companies' case studied.

Company Name	A	B	C
Products	Drilling Rods	General Engineering	Hydraulic Equipment
Number of Employees	70	120	85
Yearly Turnover (Rands)	R45 M	R45 M	R75 M
Exports	Yes	No	No
Value of Capital/ Assets	R 23 M	R 18 M	R 60 M
ISO 9000 Registration	Yes	Yes	In-process

This paper investigates determinants for successfully managing new technologies such as computer integrated manufacturing (CIM), computer numerical control (CNC) and new information technologies such as computer aided design (CAD). From literature the determinants are training, absorptive capacity, communication, leadership and research and development which are part of technology transfer models. The Force Field Analysis was used to manage organisational challenges brought by technological changes. This paper also covers business performance of the studied SMEs before and after acquiring new technology.

2. RESEARCH OBJECTIVES

(i) The major aim of this paper is to investigate determinants that are required for successfully acquiring and managing new technology.
(ii) Through the Force Field Analysis the paper investigates how management of the three SMEs handled the organisational challenges brought about by the new technology.
(iii) To evaluate the impact of new technology on business performance of these SMEs.

3. LITERATURE REVIEW

3.1. Manufacturing Strategy

Manufacturing strategy ensures a match or congruence between the company's markets and the existing and future abilities of the production system, [20]. It addresses issues that include: manufacturing capacity, production facilities, use of technology, vertical integration; quality; production planning / materials control; organisation and personnel. Four different types of manufacturing strategies exist namely market-based, product-based, capability-based and price-based, [21]. [22], identified and examined four manufacturing strategy content issues which are cost, quality, delivery and flexibility This research will focus on organisation challenges faced by SMEs in acquiring and introducing new technology that suits their chosen manufacturing strategy.

3.2. Competitive Strategies

A company can compete successfully in at least four basic ways, namely as a cost leader, a differentiation strategy, a focus strategy and flexibility, [23]. These SMEs wanted to enhance flexibility and productivity within their manufacturing workshops. This would enable them the ability to machine different products with quick cycle times, [1], and improved quality, [24].

3.3. Training

Training helps to avert failure through integrating technical, social and organisational factors, [25] as it assists subordinates to better understand their responsibilities, authority and accountability, [26], as they contribute to achieving the objectives and goals of the organisation. The aim of training is to impart new knowledge, skills and attitudes (KSA), on employees for the sole purpose of performance improvement, [27]. Training is enhanced by the application of KSA through factors such as goal setting, workload, peer support, coaching, supervisor feedback, individual motivation and job design, [28]. Modern and competitive organisations enhance their capabilities by setting up structures that foster a culture of continuous learning and information sharing, [29]. Training improves the retention capacity of qualified employees, and improves the employee motivation, [2].

3.4. Leadership

Leadership initiates change, with a new vision for the organisation, encouraging as well as motivating people to support the new initiatives, [30].Top management leadership creates goals, values and vision that guide the pursuit of business activities of an enterprise, through the promotion of creativity, developing integrated teams, defining and communicating the shared vision, (manufacturing strategy), and generating compromise, [31], [32]. A good leader creates an enabling environment through their inter-personal relationships and influences others in the change initiative, such as during the introduction of new technology, Das, et al [33]. Leaders play three roles, namely setting direction, aligning people and motivating and inspiring people, [33]. Progressive leaders keep abreast of world standards of competition, [34]; they understand the global nature of their businesses and are able to analyze current trends and market conditions, [33].

3.5. Communication

Communication involves the process of transmitting meaningful information through three levels of intrapersonal, interpersonal and organisational, [27]. Formal network follow the hierarchical structure of the organisation while the informal network follows links grown out of relationships between employees and management, [27]. Use of strategy charts was advocated by [35] as a way that would help managers to communicate and verify a company's manufacturing strategy. The diagrammatic representation of the strategy chart includes events made up of verifiable objectives, decisions and actions called events, [35].

3.6. Absorptive Capacity

Absorptive capacity is the company's ability to recognise the importance of new, external information or technology, assimilate it and apply it to commercial ends, [7], [36], [37]. The level of a company's absorptive capacity is usually a function of prior related knowledge which includes basic skills, organisational learning and knowledge of recent technological developments, [38], [39]. Several models on how a company can manage its absorptive capacity have been presented by several authors. Investment in R & D as the driver of absorptive capacity was emphasised by [7], while [39] focussed on potential absorptive capacity (knowledge acquisition and assimilation capability) and realised absorptive capacity (transformation and exploitation capability).

Other factors that affect absorptive capacity and that are a focus of this paper are: knowledge management, [40]; organisational structures, [41]; human resources, [42]; [43]; external interactions, [42]; social capital, [44] and inter-organisational fit, [45].

3.7. Business Performance

Business performance is used to monitor and control business growth and profit, drive improvement, achieve alignment with organisational goals and to reward and discipline employees, [46]; [47]. Monitoring business performance helps companies to make decisions within needed time frames, [48]. [49], reported that implementation of manufacturing strategy can positively contribute to corporate performance on issues like profit, market share and quality improvement, on time delivery and these business performance indicators will be investigated in this paper. Other business performance metrics include an evaluation of assets and liabilities of the business from the balance sheet, business cash flow, investing activities, internal comparison of cost and sales, comparison of debtor and creditor values between past and present balance sheets and customer satisfaction level through complaints and reviews from the end users, [50]

3.8. Force Field Analysis

Force Field Analysis (FFA), developed by [16], is a managerial technique that is used for planning and analysing a situation. FFA provides a framework that looks at both driving and restraining forces affecting a problem situation. Driving forces are those that favour change and restraining forces are those that resist change. FFA addresses and stimulates both individual and team creativity by defining a vision, goal or proposed change. FFA identifies the strengths that should be facilitated and weaknesses which should be minimised. FFA helps management to integrate human and organisational aspects with new technological investments, [16], [51].

The planned change issue is graphically presented in the middle, as shown in figure 1 below. Two columns are drawn, one for driving forces on the left and one for restraining forces on the right. Each force is depicted as an arrow pointing to the middle, (planned change). The diagram must present all forces that influence the planned change. Steps followed in the implementation of a FFA, [51], are:

a) Start with a well defined change issue; it must capture the current and desired situation.
b) Draw a Force Field Diagram on a flip chart. Involve all participants.
c) Elaborate and list the driving and restraining forces. Allocate them to their respective columns.
d) Discuss the validity and relevance of each force. Identify critical ones and attend to forces that can be altered if necessary.
e) Allocate a score to each force; using a numerical scale from 1 (weak) to 5 (strong). The scoring must be based on the strength of the force and the degree to which it is possible to influence the force.
f) Calculate the total score for both columns.
g) Determine whether a change is feasible. If change is appropriate strengthen the driving and weaken the restraining forces.

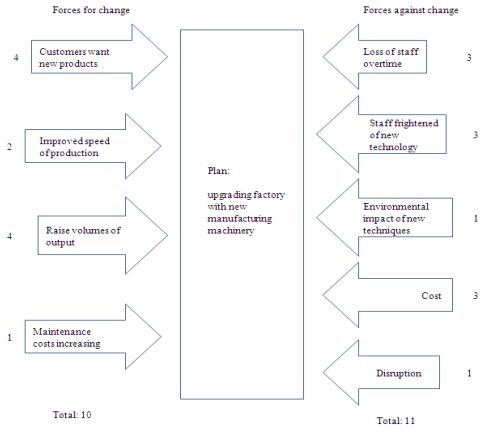

Figure 1. Force Field Analysis Diagram, [16], [46].

4. METHODOLOGY

The research methodology of this study includes relevant literature review, and detailed multiple case studies on three medium sized engineering companies. Case studies, [52] can be used to explore, describe, explain and compare while [53] stated that case studies focus on one instance's relationships and processes in a natural setting with the possibility of using multiple sources and methods for both data gathering and analysis. The triangulation method was used for data gathering as suggested by [54]. The method included extensive literature review, interviews with well prepared structured questionnaire observations and analysis of records.

Focus groups, [53], involving management and technical staff were assembled in all three SMEs. Discussions were guided by a structured questionnaire. Participants were guided on how to fill in the rankings of the Force Field Analysis, [16], [52].

5. FINDINGS

SMEs face several constraints in acquiring and setting up new technologies, including scarcity of resources, flat organisational structures and lack of technical skill. All three SMEs studied indicated that training staff was expensive and the nature of training required was not easily accessible. The research established that they are no horizontal technology transfer within the industry studied. Horizontal transfer entails transfer of technology from one company to another, generally located in different countries. Due to limited SME knowledge management it was discovered that these SMEs do not interact with technology leaders or creators directly but only through sales or distributing agencies.

SMEs do not have the capacity to enjoy vertical technology transfer. Vertical technology transfer involves transfer of technology from an R & D organisation to a firm. This type of transfer is within a country. Most SMEs do not collaborate with organisations such as CSIR-Centre for Industrial and Scientific Research who normally help industry with accessing new advanced manufacturing technologies (AMT). Due to limited resources and lack of research and development SMEs do not follow all the phases of technology transfer, [2], which are Incubation, Anticipation, Confrontation, and Follow-up, only the Implementation phase is followed.

5.1. Training

The determinant of employee training was found lacking in Company C. This was cited as a serious challenge to the implementation of new technology. Companies A and B embraced new technologies and took their employees for training in Computer Numerical Control (CNC) software applications such as MasterCam, Edge-Cam and quality

improvement courses. This was found to have enhanced their competitiveness, thus agreeing with the work of, [55]. Tangible and intangible factors, [56] were noticed in these two companies, namely reduced errors, improved quality and improved employee morale. Company A demonstrated three components of knowledge management that influence a firm's performance, [57] which are the company's ability to produce new knowledge, to build on that knowledge and to capture on subsequent spin offs.

The research could not quantify, in terms of monetary value, the return on investment made by these training activities. Another limitation was that the research did not look into the quality of training offered, the quality of the methods and techniques used, the quality of pedagogical resources used and the trainer's knowledge as suggested by [58]. Barriers to job-related training that were discovered in this research were that workers were too busy at work, courses offered were too expensive, lack of employer support and that some courses were offered at an inconvenient time and location. Most SMEs workers attended CNC courses in private colleges.

5.2. Communication

Company C exhibited poor communication, during the Force Field Analysis exercise. This was revealed through emotional barriers that included fear, mistrust and suspicion; most of the workers were withdrawn highlighting interpersonal barriers. Communication was found to be a positive determinant in companies A and B. Manufacturing strategy was well understood, [59], there was greater manager-worker trust and improved employee satisfaction. Companies A and B had sound process management, quality performance data such as defect rate, scrap and rework were effectively collected, analysed and shared this showed an improvement in their quality. This agreed with the work of [60] who established that quality metrics when calculated from reliable and valid data can be used for quality improvement purposes. These companies also exhibited formal networks of communication; it was evidenced by a much more understanding of manufacturing strategy and the need for new technology from shop floor up to management levels. The research established that all companies have very minimal investment in information systems, the link between costing office, drawing office and shop floor was found missing, giving a negative impact on overall organisational performance, [61].

5.3. Leadership

Successful leadership determinant was noticed in Companies A and B. Leaders in these companies exhibited all four key leadership factors as reported by [62] which are the ability to proactively deal with problems, keep their workers motivated, loyal and committed, ability to make effective decisions and a willingness to take appropriate risks. The research also established that employee oriented leadership found in companies A, B and supported a smooth implementation of new technology as compared to a task oriented leadership, found in company C, this agreed with the work of, [26]. Company C is owner-managed and exhibited lack of managerial expertise and organisational capabilities and this led to both poor strategic business planning and human resource management, [63] and [64]. The leadership determinant of Company C was critically weakened by the owner's management style. Companies B and C exhibited poor managerial ability to delegate adequate power and responsibility to top managers, [65].

5.4. Absorptive Capacity

Absorptive capacity is a critical determinant for successfully managing new technology. This determinant is enhanced by R & D activities, [7] as well as sound knowledge management. Management in all three SMEs showed that they had prior knowledge of computer integrated manufacturing (CIM), technologies. All SMEs understood that CIM would help them to reduce their lead times, increase flexibility and improve customer service, [66], [67]. Companies B and C exhibited slower rates of absorptive capacity due to lack of skill, lack of R & D, [7] and their organisational structures. Only Company A showed that they had invested more in their R & D, enabling it to have a higher level of absorptive capacity than companies B and C. Company A has the ability to create and produce better designed products of good quality which enables the company to match international competitiveness, [68]. Cross-function absorptive capacity that can create knowledge through job rotation, [66], was found missing in all three SMMEs.

All SMEs understood that information technology (IT), applications such as CAD / CAM can help their companies with development and growth, [69]. All SMEs had a relatively sound information technology platform. All companies had networks between management and costing offices. However the link between drawing office and the shop-floor was missing. Most workers on the shop-floor needed training on using the IT tools especially on programming CNC machines.

5.5. Business Performance

From the questionnaire responses a table of business performance metrics was created for analysis as shown in Table 2 below.

Table 2. Summary of Business Performance metrics from Questionnaire response

Company	A	B	C
Market share	Moderate	Low	Low
Sales growth	Moderate	Low	Moderate
Share holder return	High	High	Low
Customer satisfaction	High	Moderate	Moderate
Financial Performance	High	Low	Moderate
Return on capital	High	Low	Moderate
Quality	High	High	Moderate
Investment in New Technology	High Tech	Moderate Tech	Moderate Tech

Companies A and B were found to have flat organisational structures, this enabled them to be flexible, adaptable and responded quickly to changes in their business environment, Garengo, [70]. In both companies customer requirements were met through continued innovation of products and better communication, [71]. These were the only companies that provided meaningful performance data of quality and sales contribution, from 2010 to 2012, on which a correlation of improved quality and business performance was established, Table 5.5.2 and Table 5.5.3. Histogram graphs of delivery reliability were drawn for the period 2010 to 2012, for company A.

All companies did not disclose their financial information and balance sheets making it difficult to analyse Return on Investments, Assets, Cash flow and profits. The research did

not cover external performance due to unavailability of data. Warranty costs and the rate of field repairs or service were not obtained although the numbers of warranty claims against sales were very low.

From performance data supplied by Company A, on the performance of drilling rods' percent good quality (X) and sales contribution (Y) for the period 2009 to 2011, a strong positive correlation of 0.868 was established as shown in Table 3 below.

Table 3.

	X	Y	XY	x^2	Y^2
mar	58	62	3596	3364	3844
jun	62	60	3720	3844	3600
sep	65	64	4160	4225	4096
dec	60	67	4020	3600	4489
mar	64	70	4480	4096	4900
jun	70	75	5250	4900	5625
sep	73	72	5256	5329	5184
dec	77	74	5698	5929	5476
mar	80	76	6080	6400	5776
jun	82	77	6314	6724	5929
	691	697	48574	48411	48919
	$\bar{x}$	69.1,		S_x =	8.141867
	$\dot{y}$	69.7,		S_y =	5.814637
	S_{xy} =	41.13		**r =**	**0.868785**

A similar analysis was done for company B. on the performance good quality (X) and sales contribution (Y) for the period 2010 to 2012, a strong positive correlation of 0.936 was established as shown in Table 4.

Table 4.

	X	Y	XY	x^2	Y^2
mar	60	65	3900	3600	4225
jun	62	63	3906	3844	3969
sep	64	67	4288	4096	4489
dec	63	70	4410	3969	4900
mar	66	68	4488	4356	4624
jun	68	73	4964	4624	5329
sep	70	76	5320	4900	5776
dec	72	79	5688	5184	6241
mar	75	80	6000	5625	6400
jun	76	78	5928	5776	6084
	676	719	48892	45974	52037
	$\bar{x}$	67.6,	S_x =	5.257376	
	$\dot{y}$	71.9,	S_y =	5.838664	
	S_{xy}	28.76	**r =**	**0.936928**	

Delivery performance measurement is another metric for business perfomance. Typical measures for delivery reliability are % customers' orders met in full, % order lines met in full, % order value met and % line item quantities met, [23]. Delivery reliabilty histograms were drawn for the first two quarters of 2010 and 2012 for Company A only.

Figure 2 and 3 show that delivery reliability of Company A has improved. In the first quarter of 2010, 90 % of of their orders could not meet the delivery due dates, while the first quarter of 2012 shows that only 45 % of their orders still miss the delivery due date.

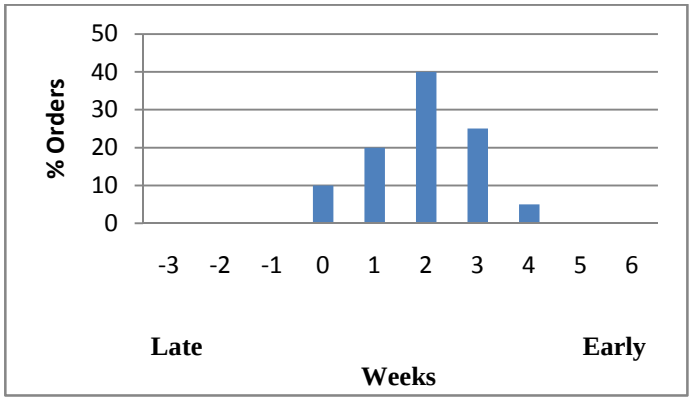

Figure 2. Drilling Rods -Delivery Reliability for first quarter 2010

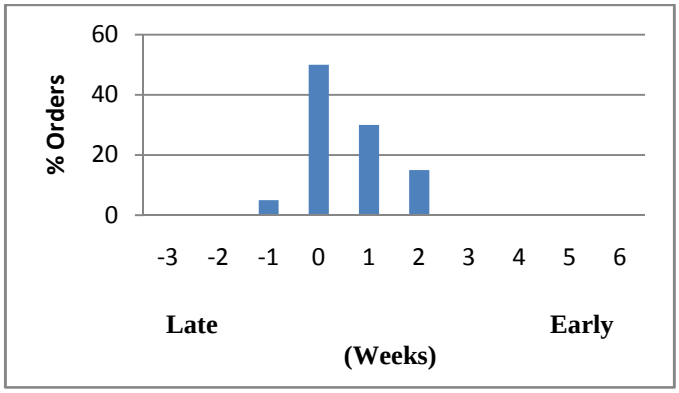

Figure 3. Drilling Rods Delivery Reliability for first quarter 2012

A similar analysis was done for Company B. and it was noticed that they has been an improvement in their deliveries. About 30 % of their products still miss delivery due dates by about two weeks.

6. LIMITATIONS

Few SMMEs were studied making it impossible to generalise the results. Universities offering AMT courses were not visited, but from their literature it was evident that they interact with SMMEs.

7. RECOMMENDATIONS

Two major determinants for management of new technology in SMEs that were found to be critically lacking were collaboration between educational centres that offer AMT courses and the lack of resources and technical skill in SMEs to nature Research and Development activities. The ability to acquire, diffuse and master new technologies as well as innovate can be achieved in many ways for example clustering and inter-firm cooperation or business linkages. Technology drivers that must be natured in an organisation for successful skills development are R & D capabilities, ability to attract Foreign Direct Investment (FDI), access to finance and good infrastructure. South Africa needs to set up technology diffusion centres which can be led by Universities, Further Education Technology Colleges or manufacturing technology incubators which can have operations that are similar to the Centre for Manufacturing Information Technology run by Georgia Institute of Technology in America and Japan's prefectural and municipal technology centres, [72]. The current structure and focus of most South African Universities is not responsive to SMEs technological needs. Only three universities out of twenty five have an established centre for

Advanced Manufacturing, namely North West University (NWU), Vaal University of Technology and Nelson Mandela Metropolitan University (NMMU). These three universities work hand in hand with Government support agencies such as The Department of Trade and Industry (DTI), Small Enterprise Development Agency (SEDA) and Centre for Scientific and Industrial Research (CSIR). However due to lack of external knowledge most SMEs do not know of these services.

SMEs are encouraged to develop industry portals that can aggregate flexibility and agility despite their lack of resources, [73]. Through alliances, external networks, [74]. SMEs can improve their competitiveness by sharing product, manufacturing technology, [2], marketing and R & D know how and resources, [75]. Uncertainty and vulnerability associated with new technology will be reduced, [76].

8. CONCLUSION

For successful management of new technology the Impediments to technology diffusion are that SMEs face uncertainty, information, time and learning costs, lack of technical expertise, weak financial mechanisms and poorly organised inter-firm relationships. Many SMEs are reluctant to share technical, training and other business information within their sector for fear of competition. SMEs are not willing to form or join clusters which they can use to advance their operations. Challenges faced by SMEs in acquiring and using new technology can be solved by developing capabilities in external knowledge acquisition, improved man management skills and by leasing with local support agencies such as business chambers, technical colleges and universities.

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