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Operations Management's Dual Upbringing: Impact on Key Theories

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Abstract: *Intrigued by academic's views on operations management which they claim is an applied subject with very little theory, and its dual upbringing in both Industrial Engineering and the Social Sciences; this paper embarks on a reflection to uncover the impact of dual upbringing on key theories in operations management. The reflection reveals pair of core drivers on each theory, including location and profitability, flow and productivity, performance and competitivity, waste elimination and productivity, skills and competitivity, design and performance. The literature review of identified pairs of core drivers points to an attribute of polarity in operations management. Longitudinal data from the Manufacturing Circle of South Africa is used to carry out statistical analysis - principally correlation and regression. It is observed that, practically, operations managers instead of "either/or" choice they take "both/end" approach when facing with polarity; nonetheless, the literature has highlighted the likelihood of manufacturing firms engaging in "either/or" approach based on impact of competition and the contexts where a specific behaviour could be required or might prevail. An interesting theoretical implication of the theory of polarity is that operations management involves a feedback mechanism from Industrial Engineering to Social Sciences. In view of the competition faced in business environment, the rapidly evolving business environments, and the slowly evolving internal resources of manufacturing firms, competitive foresight is identified as the missing link. The practical implication of competitive foresight is that basic elements of anticipatory and systemic thinking need to be incorporated in the developmental programs of operations managers to prevail over the current dominating responsive routines approach.*

Keywords – manufacturing, performance, process management

INTRODUCTION

Operations management is an academic discipline that studies how goods get manufactured, and services get delivered with the goal to increase efficiency in production and service delivery. Theory in operations management underpins efficiency in manufacturing firms through striving to meet the customer's requirements to the highest possible standard with the least amount of resources needed. Operations management is "a body of knowledge, experience and techniques covering topics encompassing process design, layout, production planning, inventory control, quality management and control, capacity planning and workforce management" (Johnston, 1994; Wilson, 2018; Wolniak, 2020). Schmenner and Swink (1998) maintain that, as a field of study, operations management is highly applied, to the point that it is almost atheoretical. Boer Harry at al. (2015) argue that naturally every researcher is striving to make "theoretical contribution" to the body of science, this however, has proven to be a source of confusion and frustration in the Social Sciences. They confirm that "this is due to the applied nature of operations management, which stems from its dual upbringing in both Industrial Engineering and Social Sciences". The complexity of Social Sciences problem solving relatively to Engineering tradition is highlighted by the fact that, academics in operations management seek a theory with practical relevance to predict the relationship between variables. Chase (1980) highlights the conundrum nature of operations management and posits that generally "operations management research does not draw upon management theory". Slack et al. (2004) point out that "while other academic disciplines are directly connected to base theoretical sciences, operations management underpinnings are more fragmented".

Beyond the above, academics have studied manufacturing firms' size, age in relation to growth and their impact on performance with respect to "learning by doing and structural inertia"; and divergent findings were reported (Noordin & Mohtar, 2014; Pervan et al., 2017; Ofuan et al., 2016; Mallinguh, et al., 2020; and Zhou and Gumbo, 2021). Several academics have advocated for business agility; however, this allows manufacturing firms to be "more responsive to change, hasten the time to market, and reduce costs without sacrificing quality" (Alberts, 2010; Alberts, 2011). In general, manufacturing firms have embedded the ability of forecasting, reacting, executing strategies, and maintaining lean and agile operations. Nevertheless, the pertinent question is - how can operations managers cope with divergent realities such as the competition faced in business environment, the rapidly evolving business environments, and the slowly evolving internal resources of manufacturing firms. These divergent realities still position operations managers on a responsive posture, it seems that there is still a missing link with regards to anticipating the future change.

In light of the above, it becomes important to take stock of operations management theoretical underpinnings to examine the influence of operations management's dual upbringing on key theories in operations management; hence, the purpose of this study is firstly to reflect on selected fundamental theories in operations management; secondly, to attempt to identify the core drivers of these theories and the probable implications; and thirdly, to explore a suitable approach concerning the triangulate aspect of the competition faced in business environment, the rapidly evolving business environments, and the slowly evolving internal resources of manufacturing firms.

Operations management theory

Hempel (1965) and Bacharach (1989) highlight the need to differentiate description from theory. They reckon that social science research predominantly makes use of typology, category, and metaphor to describe phenomena. It is worth acknowledging that developing

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theory is difficult and majority of studies in any operations management field contribute to existing theory. Typical questions addressed in operations management context were summarized by Boer Harry at al. (2015) and include: "what processes and practices apply in which contexts, what relationships hold or do not hold in which contexts and where do methods work and do not work or how do they vary in different contexts". Operations management is generally an applied subject, with little theory; nevertheless, several academics developed theories, and seven main theories were selected, for the purpose of this research:

1. "Theory of location"
2. "Theory of Process Choice"
3. "Theory of Swift and Even Flow"
4. "Theory of Lean Manufacturing"
5. "Theory of Performance Frontiers"
6. "Theory of Constraints"
7. "Queuing theory"

Table I provides a succinct summary of each theory as well as their 'propositions' or 'laws' and more importantly the core drivers of each theory.

Table I Summary on selected key theories in operations management

Theory	Academics	Essence	Propositions/Laws	Core drivers
Theory of location	Alfred Weber (1929)	This theory states that "the optimal location of an industry is determined by various factors such as labour and transportation cost (market & raw materials)".	This theory has three key propositions: (1) "cost minimization", (2) "revenue or benefit maximization", and (3) "profit or net benefit maximization".	Location and Profitability
"Theory of Process Choice"	"Hayes and Wheelwright (1979)"	This theory states that "firms adopt different types of process to manufacture products resulting in strategic trade-off between cost and flexibility (volume and variety of products): High	This theory has two key propositions: (1) "Choice over the type of process to adopt to manufacture products or deliver services". (2) "Trade-off between producing volume and variety of products"	Design and Performance

		volume processes produces cheap goods, but without any flexibility; while low volume products can be customised, but their production will be costly".		
"Theory of Swift and Even Flow"	"Schmenner and Swink (1998)"	This theory states that "productivity rises with the speed of flow of materials through a process, and reduces with increases in the variability associated with the flow".	There are three laws associated with this Theory: (1) "Law of variability: the greater the randomness of the process, the lower the productivity". (2) "Law of variability: the greater the variability of the requirements of the process, the lower the productivity". (3) "Law of bottlenecks: the greater the difference in the rate of flow through stages in a process, the less productive the process".	Flow and Productivity
"Theory of Performanc e Frontiers"	"Schmenner and Swink (1998)"	This theory states that "a performance frontier is the maximum output that can be produced from any given combination of inputs, given their technical considerations. It suggests that an organization will have an asset frontier that represents the maximum performance under	There are three laws associated with this Theory: (1) Law of cumulative capabilities: an improvement in one manufacturing capability leads to improvements in others. (2) Law of diminishing returns: as improvement (or betterment) moves a manufacturing plant nearer its frontier more resources will be required for each	Performance and Competitivity

		optimal asset capability and utilization, and an operating frontier which represents the achievable performance under the current strategies and policies".	additional incremental benefit. (3) "Law of diminishing synergy: the law of cumulative capabilities suggests that there is synergy between policies and procedures. This synergy diminishes as a plant approaches its asset frontier".	
Theory of Lean Manufacturing	Taiichi Ohno (1960)	This theory basically states that "productivity is enhanced by applying principles designed to eliminate waste of all kinds. Seven types of waste are identified: Transportation, Inventory, Motion, Waiting, Overproduction, Overprocessing, and Defects"	There are four laws associated with the Theory: (1) "Law of scientific methods: labour productivity is improved by applying scientific management principles". (2) "Law of quality: productivity improves as quality improves, since waste is eliminated". (3) "Law of limited tasks: factories that perform a limited number of tasks will be more productive than similar factories with a broad range of tasks". (4) "Law of value added: a process will be more productive if non-value-added steps are reduced or eliminated".	Waste elimination and Productivity
"Theory of Constraints"	"Goldratt and Cox (1984)"	This theory states that "every process has a single constraint (bottleneck) that stands in the way of	There are five steps to remove constraints: (1) "Identify the constraint. To achieve your goal, you must	Skills and Competitivity

		achieving the goal of improving profit. Management should focus on systematically improving that constraint until it is no longer the limiting factor as only improvements to the constraint will further the goal".	alleviate the current bottleneck...." (2) "Exploit the constraint...." (3) "Subordinate everything else to the constraint...." (4) "Elevate the constraint ..." (5) "Avoid inertia and repeat the process".	Flow and Productivity
Queuing theory	Erlang A. K. (1909)	The queuing theory at its most basic level, involves "the analysis of arrivals (customer/parts) at a facility, and an analysis of the processes currently in place with the end goal to identify any flaws in the system to build more efficient and cost-effective workflow s ystems".	Little's law is associated with this Theory (John Little, 1954): (1) "The average number of customers/parts in a stationary system (L) is equal to the long term average effective arrival rate (λ) multiplied by the average time (W) that a customer spends in the system".	Workflow and Productiv ity

The importance of theory is to explain facts and enlighten humankind on the observed phenomena. Boer Harry at al. (2015) emphasize the dual upbringing of operations management in both industrial engineering and the social sciences; similarly, the reflection on the key selected theories of operations management is enlightening since it portrays the characteristic of dual upbringing in the core drivers. It appears that, from this dual upbringing in both industrial engineering and the social sciences, derives the unique nature of operating management where originates "an attribute of polarity". The following section will explore polarity in operations management through the lens of core drivers identified from selected theories in operations management.

The theory of polarity

In an attempt to grasp operations management theory while bridging gaps between academics and practitioners it became important to take stock of operations management theoretical underpinnings to be able to comprehend the journey of operations management thus far. Bearing in mind the dual upbringing of operations management, Industrial Engineering field "devises efficient systems that integrate workers, machines, materials, information, and energy to make a product or provide a service". On the other hand, the field of Social Sciences deals with human behaviour in its societal aspects. This enables us to take a view of a "theory of polarity" in operations management. "A polarity is a pair of interdependent positive concepts that need to work together for sustainable and optimal effectiveness" (e.g., Consistency & Flexibility), contrary to opposite concepts, with one positive and one negative pole (Johnson, 2014); In other words, two mutually interdependent variables that co-exist over time. The reflection on the selected key theories in operations management reveals that there is polarity on the identified core drivers. To be successful over time, operations managers should choose both poles and capitalize on each. The following subsections will discuss the identified core drivers which led to the suggestion of the theory of polarity.

- Performance and competitivity

At the era of globalization, competition has also become global. Globalization has increased access to foreign markets by opening new markets worldwide for manufacturing firms; this leads to greater competition in the marketplace in various ways. "With increasing levels of competition, manufacturing firms are under pressure to strategically develop and deploy their capabilities to generate competitive advantage" (Nand and Singh, 2014; Vilkas et al., 2022). Amit and Schoemaker (1993) suggest that "capabilities describe the method by which resources are arranged to effect a desired end". The traditional competitive capabilities are "cost efficiency, quality, delivery and flexibility" as suggested by Hayes and Wheelwright (1984) and Hill (1995). Avella et al., (2011) and Sousa et al. (2024) explain that substantial studies were carried out to confirm that manufacturing firms handle these competitive capabilities in two distinct ways, namely "trade-off and cumulative capabilities models". While other manufacturing firms apply the "cumulative capabilities model where they compete along multiple capabilities simultaneously" (Nakane, 1986; Ferdows & De Meyer, 1990; Noble, 1995; Flynn & Flynn, 2004; Madi & Munapo, 2016), several manufacturing firms apply the "trade-off model where they selectively focus on one or two capabilities to compete on, while devaluing the other capabilities as competitive priorities" (Skinner, 1969; Hayes & Wheelwright, 1984; Boyer & Lewis, 2002; Schoenherr et al. 2012).

The development and arrangement of competitive capabilities is strategic for manufacturing firms and provide prospects for competitive advantage. Authors argue that "competitive capabilities directly demonstrate and indicate the economic outcome of a firm" (Koufteros et al., 2002; Hallgren et al., 2011). Schmenner and Swink (1998) propose the "theory of performance frontiers, positing the existence of asset and operating frontiers". According to this model, "competitive capabilities are typically cumulative for manufacturing firms that are away from their frontier; however, once near or on the frontier, manufacturing firms will have to make trade-offs to alter their competitive position" (Schmenner & Swink, 1998; Amoako-Gyampah & Meredith, 2007; Rosenzweig & Easton, 2010). By taking a longitudinal view of manufacturing firms' operations, the theory of performance frontier supports the theory of polarity considering trade-off and cumulative capabilities as two poles. From an operational point of view these positive forces should be managed since trade-off and cumulative capabilities will occur relatively to the position of the firm to its frontiers, also bearing in mind the extent of competition in the business environment, and the fact that frontiers could be shifted. Hence, to be successful over time, operations managers should take "both/and" approach instead of "either/or" and manage the positive and negative of each pole depending on the level of competition whitin the business environment.

In addition to the above, Vastag (2000) covers issues related to "addressing competition among firms with regards to achieving sustained competitive advantage", while Nand and Singh (2014) suggest that "a firm's choice on trade-off and cumulative capabilities depends on the level of competition faced in its business environment". This implies that the performance of the manufacturing firm and its competitivity are two positive poles within the business environment. By taking a longitudinal view, this concept provides support to the theory of polarity where performance and competitivity are two poles depending on firm's behaviour and business environment.

- Design and performance

The manufacturing firms find themselves outstretched by rapidly evolving business environments and slowly evolving internal resources. According to Leseure (2010) "these internal and external dynamics should each contribute to facilitate the alignment of resources with market requirements instead of counteracting each other". Developing and deploying a new technology in a production system is time-consuming and it probably takes several years before it generates financial returns (Kim and Oh, 2024; Albukhitan, 2020; Avenyo and Bell, 2022). Hence, there is a fundamental 'clock differential', which required stakeholders' long-term commitment. To elucidate this with an example, if a manufacturing firm designed with large excess capacity ultimately falls short in securing the intended market share, operations manager will be compelled to run the large, under-utilised asset at a loss.

Operations managers directly control internal performance measures by "investing, training, staffing, and motivating" to improve performance on core operational competitive capabilities ("cost, quality, delivery, and flexibility"). In contrast, "the external performance is assessed by several different and independent parties through a process of value perception" as highlighted by Leseure (2010). Practically, market dynamics are extremely volatile compared to resource dynamics, which exacerbates the alignment of internal performance with external performance. For example, while on the one hand, competitors regularly launch new products and introduce higher levels of service, on the other hand, customer preference is subjected to fashions, weather, political and socio-economic conditions contributing therefore to a volatile and turbulent market.

Based on the above, the pertinent question is - How can operations managers cope with divergent realities such as rapid evolving markets and customers demand patterns, and in contrast slow evolving internal systems which are difficult to change and demand long-term stakeholders' commitments? From this point of view design and performance are portrayed as two positive poles that should be managed; supporting therefore the theory of polarity where operations managers will have to align resources with market requirements and capitalize on both poles to achieve the greater purpose of staying afloat in business. Katayama and Bennett (1999) state that "developing strategic insight coupled with management actions seeking to improve the adaptability of the manufacturing firm to fit evolving needs is vital". Failing to quickly reconfigure the resources could result in the manufacturing firm becoming a loss-making operation.

- Location and profitability

Weber (1929) theory of location assumptions include "the transportation costs of commodities depending on distance and weight; Also, labor is geographically fixed, and the existence of uniformity in terms of manufacturing firms' political, physical, and technological locality". Several academics have built on Weber's theory, including Moses (1958) and Smith (1971) who emphasis respectively on industrial linkages and intertwinedness of production and locational behaviour. According to Yang and Lee (1997), "to reach the right location decision, it is most important to select, analyse, and evaluate the right location criteria". Schmidt et al. (2017) and Bjelkemyr et al. (2013) claims that there are several location criteria influencing location decisions as portrayed in the table II.

Table II Summary on location decision by author

Academics	Location criteria	Number of criteria	Approach
Goetschalckx, Vidal, and Dogan (2002)	"Stochastic, taxation and cash flow, non-international and trade barriers"	four	Strategic logistic models
Farahani, SteadieSeifi, and Asgari (2010)	"Cost, environment risk, coverage, service level and effectiveness, profit, and other criteria"	six	Multi-criteria approach to localization problems
Ferdows (1997)	"Government policies, market, skill and knowledge, risk, competition, and production and logistics cost"	six	Drivers behind global spread of production
Bergeron et al. (2005)	"Geography and culture, environment, workforce, and cost and ROI"	four	Classification of factors by site selection model
Galan, Gonzalez and Zuñiga (2007)	"Cost factors, market factors, infrastructure and technical factors,	five	Classification by factors

	political and legal factors, and social and cultural factors"		
Mentzer (2008)	"Land, labour, capital, sources, production, markets, and logistics"	seven	Factors in effective facility

Yang and Lee (1997) extend the above classification approach by categorising factors in "quantitative factors which are used for numerical values (i.e., cost, distance and revenue), and qualitative factors such as policy, law and quality of work environment, which are difficult to measure in numbers". Bjelkemyr et al. (2013) reckon that usually location decision relies on availability and accessibility of information. They highlight that "business intelligence is often difficult to obtain or problematic to translate into economical terms", nonetheless, this does not insinuate that qualitative factors have no impact on profitability of the location. Therefore, location and profitability are portrayed as two positive poles. This concept provides support to the theory of polarity in that location and profitability appear to be two poles that keep things balanced. In addition, over the years, local, regional, or global dynamics could influence the outcome of a location and thereby the firm profitability. A manufacturing firm location decision has long-term effects on the manufacturing firm's profitability; inadequate business intelligence might trigger dire consequences.

- Flow and productivity

Shankar and Aroulmoji (2020) and Sreekumar et al. (2018) suggest that "productivity is one of the most ambiguous terminologies that exist". However, the swift and even flow theory holds that "productivity for any process—be it labour productivity, machine productivity, materials productivity, or total factor productivity—rises with the speed by which materials flow through the process, and it falls with increases in the variability associated with the flow, the variability associated with the demand on the process, or with steps in the process" (Schmenner and Swink, 1998). According Taiichi Ohno (1960), work is divided into value-added and non-value-added work. Non-value-added work includes the "classic seven wastes of "Shigeo Shingo": overproduction, waiting, transportation, unnecessary processing steps, stocks, motion, and defects" (Hall, 1987). This implies that, materials move swiftly throughout a process if there is diminishing variability associated with the flow and the non-value-added steps are either removed or significantly minimised. Similarly, "materials can move swiftly only if there are no bottlenecks or other impediments to flow in the way" (Goldratt and Cox, 1984).

The theory of queuing, swift-even flow, lean manufacturing, and constraints are concerned with the productivity of manufacturing firms; Woldeyohannes and Geremew (2025) argue that productivity is a key metric for manufacturing firms. "A more general phenomenon addresses why it is that some manufacturing firms appear to outperform their rivals in many dimensions of performance, not only productivity" (Schmenner and Swink, 1998). While other firms appear to be faced with strategic "either/or" choices about what to do, the best in class seems to be moving along with strategic "both/and" choices, therefore strongly supporting the theory of polarity. "A swift flow but uneven or inversely and slow flow but even would have dire consequences on productivity" as highlighted by Schmenner and Swink (1998). The flow of materials is intimately linked to productivity if not to the business turnover.

- Skills and competitivity

Manufacturing firms, "like organisms, evolve and in the process adapt to changes in both their internal and external environments" as suggested by Teruel-Carrizosa (2006). By drawing an analogy between the theory of evolution in biology and the evolution of manufacturing firms, Nelson and Winter (1982) concluded that "firms survive and expand through technological competition". They use the concept of satisfying behaviour to explain that "individuals will naturally seek to apply the simplest rules, it is only in the case where satisfaction is not achieved that individuals will actively explore better ways of doing things". Furthermore, they termed 'process routines' the combination of both a resource and a risk. According to their theory, the challenge of process management is that "even though at an organisational level survival and competitiveness are the result of process adaptation and innovation, the individuals executing these processes exhibit satisfying behaviour rather than innovative behaviour".

In an attempt to explain a more general phenomenon as to why two manufacturing firms of similar bundles of resources have different performance and similarly why investments by two different manufacturing firms may not result in the same outcomes, writers suggest that "manufacturing firms are able to create and sustain competitive advantages through the collection and integration of rare, valuable, inimitable, and non-substitutable resources" (Hitt et al., 2016; Sirmon et al., 2011; Chikan et al., 2022). Barney (1991) extends this concept to suggest that "in order to sustain that advantage over time, the resources must also be difficult to imitate and non-substitutable by other firms' resources". In mobilising the manufacturing firm's resources, operations managers should carefully choose, foster, and bundle together tangible and intangible resources to create and sustain competitive capabilities (Madi, 2025a**)**. Hitt et al., (2001) and Hitt et al., (2006) claim that "intangible resources are more likely to produce a competitive advantage because their value is more difficult to imitate and their functions more difficult to substitute". Nelson and Winter (1982) argue that "the performance of manufacturing firms is determined by the routines that they possess, and the routines possessed by the other firms and economic units with whom the firms interact". Thus, routines become a nexus between the behaviour of the firm and the business environment. This concept provides support to the theory of polarity where skills and competitivity are portrayed as two poles. Operations managers should constantly assess how well they are meeting business needs at both poles and quickly integrate learning. In addition, it has been established that social forces and relational forces positively impact employee productivity (Mayo, 1933; Rosnaida,

2024) and emphasizing on organizational structure and human behavior increases productivity (Fayol, 1916; Job, 2022) these concepts corroborate to the polarity between skills and competitivity and highlight a polarity between socials factors and productivity.

It has been concluded from the above review that the core drivers of operations management theories are rooted in the combination of industrial engineering metrics such as flow, quantity, location, design, performance, and social sciences aspects like human resource, social factors, organisation learning, while the combination is measured in economics dimensions such as productivity. This provides insight into the dual upbringing of operations management and the origin of polarity. It seems that polarity is the overarching principle in the key theories of operations management. An interesting theoretical implication of the theory of polarity is that operations management involves a feedback mechanism from Industrial Engineering to Social Sciences.

RESEARCH METHODOLOGY

Seven key theories are selected to assess the impact of operations management's dual upbringing. The review approach of these theories highlights that each has a pair of core drivers which substantiate the attribute of polarity in operations management. The research briefly explores the triangulate aspects of the competition faced in business environment, the rapidly evolving business environments, and the slowly evolving internal resources of manufacturing firms. Empirical data was used to test the relationship of performance measures associated with the core drivers.

Academics adopt various research methodologies to study the relations between performance measurements, including correlation (Ferdows and de Meyer, 1990; White, 1996), regression (Noble, 1995; Flynn and Flynn, 2004; Peng et al., 2008), path analysis (Rosenzweig and Roth, 2004), and structural equation modelling (Größler and Grübner, 2006). This study particularly selects correlation and regression analysis, since they allow to identify the associations between variables occurring in some data, the combination of correlation and regression can show both the magnitude of such an association and its statistical significance (Akintunde, 2012).

The empirical statistical analysis is carried out using the data compiled by Pan-African Investment and Research Services on behalf of the Manufacturing Circle of South Africa. The data are made up of fifty-four manufacturing firms of different size and from various industrial sectors. The survey was compiled on a quarterly basis over a period of four years from 2010 to 2014 since the research is purposefully a longitudinal study. Longitudinal research in operations management is an observational study that collects data on an entity or many entities simultaneously throughout a period of time to analyse the relations between variables to uncover the cause-and-effect association and examine the perceptible antecedents and precedents as highlighted by Akintunde (2012). Longitudinal data portray information on performance measures of interest in a time series. The quarterly data was used to study the relations between Productivity, Throughput, Inventory, Suppliers performance, Cost, Employment (related to location), Delivery speed, and Skills. The actual performance measures used were: "status of skills availability in the industry, throughput or level/volume of general business output (non-monetary measures), inventory or level/volume of overall purchased stock of materials and goods used in the normal business or activities (non-monetary measures), delivery speed or the difference between new sales orders and the backlog of sales orders, the level of labour productivity over the quarter", the supplier performance over the quarter, the level of employment over the quarter and the level of prices over the quarter.

RESULTS AND DISCUSSION

Statistical analysis results are presented in Tables III to VI below. In order to test the research question, correlation and regression analysis were performed. The results reveal that the majority of pairs of performance measures of interest (Productivity, Throughput, Delivery speed, Skills, Inventory, Suppliers performance, Cost, and Employment (related to location) have moderate to strong positive correlation coefficients: Productivity – skills (60.3%), Throughput – skills (58.3%), Productivity – throughput (30.7%), Delivery speed – Throughput (78.8%), Delivery speed – productivity (59.1%), Delivery speed – Skills (70.1%), Cost – Skills (47.9%), Cost – Throughput (46.1%), Employment – Throughput (54.7%), Employment – Delivery speed (42.7%); however, Suppliers performance – Productivity and Suppliers performance – Delivery speed have negative correlation respectively of (-44.8%) and (-31.6%). The Correlation results are presented in the table III.

Table III Results of statistical analysis – Correlation.

	Productivity	Throughput	Skills	Inventory	Delivery speed	Suppliers performance	Cost	Employment
Productivity	1							
Throughput	0.307803	1						
Skills	0.603729	0.583218	1					
Inventory	0.477855	0.295228	0.344259	1				
Delivery speed	0.591884	0.788401	0.701243	0.176578	1			
Suppliers performance	-0.448311	-0.128552	-0.244443	-0.269422	-0.316346	1		
Cost	0.110565	0.461381	0.479194	0.070145	0.066439	0.198379	1	
Employment	0.247888	0.547089	0.180453	0.458381	0.427101	-0.060043	0.138632	1

Productivity is a key metric for manufacturing firms – since it was often identified as core driver in one way or another during the review of key operations management's theories. To assess polarity, productivity was used as dependent variable in the regression analysis. The regression analysis summary output is presented in Table IV, V & VI. Overall, the results of regression analysis showed the utility of the predictive model was significant, F = 9.93334, $R2$ = 0.920565, p< 0.0062095. All of the predictors explain a large amount of the variance between the variables (92%). The results showed that perceived Skills, Inventory, Delivery speed, Throughput, were significant positive predictors of productivity (respectively t= -7.026, p< 0.00041, t= -4.43, p= 0.0044, t= 4.501, p= 0.00409, and t= -2.16, p= 0.073). In addition, the results showed that Cost, Employment and Supplier performance (t= -1.86, p= 0.111; t= -0.59, p= 0.57 and t= 0.27, p= 0.79 respectively) were not significant predictor of productivity.

Table IV Results of statistical analysis – Regression statistics.

Regression Statistics	
Multiple R	0.9594608
R Square	0.920565
Adjusted R Square	0.8278907
Standard Error	1.4356473
Observations	14

Table V Results of statistical analysis – Anova.

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	143.314	20.473	9.93334	0.0062095
Residual	6	12.366	2.061		
Total	13	155.681			

Table VI Results of statistical analysis – Regression.

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	28.048	6.212	4.5153123	0.0040376	12.848	43.247	12.848	43.247
Throughput	-2.768	1.280	-2.1624486	0.073827	-5.899	0.364	-5.899	0.364
Skills	-1.308	0.186	-7.026546	0.0004149	-1.763	-0.852	-1.763	-0.852
Inventory	-167.731	37.838	-4.4328891	0.0044094	-260.317	-75.145	-260.317	-75.145
Delivery speed	159.788	35.495	4.5016994	0.0040965	72.935	246.641	72.935	246.641
Suppliers performance	0.123	0.447	0.2761263	0.7917156	-0.971	1.218	-0.971	1.218
Cost	-1.027	0.550	-1.8661587	0.1112698	-2.373	0.320	-2.373	0.320
Employment	-0.397	0.668	-0.5943194	0.574009	-2.030	1.237	-2.030	1.237

The extent to which these results support the proposed theory of polarity is discussed below. The combination of correlation results and regression t Stat and P-value revealed that, practically, operations managers instead of “either/or” choices, they take “both/and” approach when facing with polarity. This is in line with the findings on the review of key theories in operations management and of identified core drivers. Even though analysis here suggests that these polarities are interdependent rather than mutually exclusive; It has been commonplace to view these types of polarities as “either/or” choices (Johnson, 2014). Viewed from this perspective, the role of management becomes balancing the perceived rival perspectives. The core drivers of each theory integrate factors from industrial engineering and social sciences, this is due to the dual upbringing of operations management in both sciences. Industrial engineering is business-driven and people-orientated and strives to eradicate wastefulness in operations by integrating means of production to manufacture a product or provide service; while social sciences on the other hand provide a broader understanding of human behavior, ethics, and societal implications.

Nand and Singh (2014) elaborate on the probability of manufacturing firms engaging in “either/or” approach based on impact of competition. While they argue that the strategy choice is substantially influenced by the extent of competition faced, the performance frontiers theory put forward probable scenarios where specific behaviour could be required or might prevail. Nonetheless, this study suggests that, by taking a longitudinal perspective and to ensure that the manufacturing firms remain in business, operations managers need to take “both/and” approach and manage the positive and negative of each pole depending on the competition in the business environments. The proposition of the theory of polarity is that operations managers should set strategy to alter the natural diminishing attraction between these positive poles, to ensure that these pairs of core drivers work together for sustainable and optimal effectiveness of the manufacturing firms.

Figure I depicts a schematic summary of aspects included within the boundary of the research study.

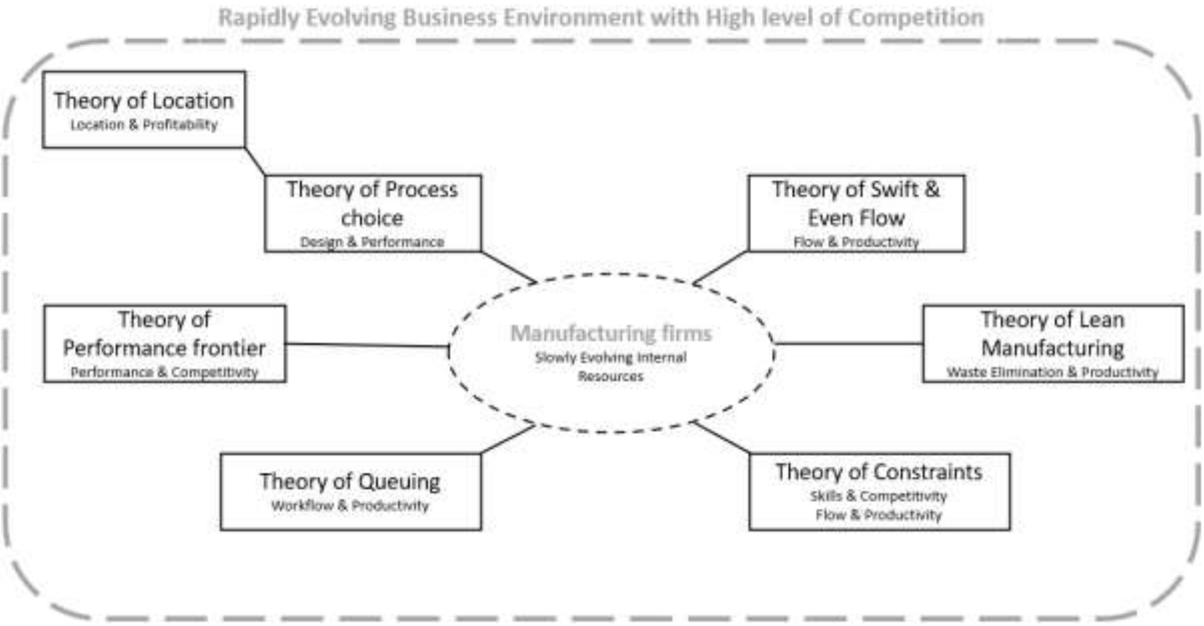

Figure I Schematic summary of the research

It appears that the developmental path of theory in operations management has so far covers various aspects of the field from location and process choice of the manufacturing to cutting edge theories to ensure that manufacturing firms are optimally operated, including queuing theory, lean manufacturing, swift even flow, performance frontier and theory of constraints. In light of figure I, a horizon has opened up to explore the triangulate aspect of the competition faced in business environment, the rapidly evolving business environments, and the slowly evolving internal resources of manufacturing firms. The next section will attempt to explore a suitable approach for operations managers regarding this horizon.

The theory of competitive foresight

In view of the competition faced in the business environments, the rapidly evolving business environments, and the slowly evolving internal resources of manufacturing firms, we suggest that competitive foresight is the missing link. This is on the backdrop that there is increasing criticisms on economic forecasting literature due to inaccuracy of forecasts which usually triggers serious ramifications as highlighted by O'Mahony et al., (2024). Economic foresight, "in public policy, is a practice of considering the future evolution of an economy to support better analysis or improved decision-making" (Windsor, 2021; O'Mahony et al., 2024). "Foresight is a purposeful process of developing knowledge about the future of a given unit of analysis or a system of actors" (Miles et al., 2008a; Miles et al., 2008b; Madi K., 2025b; Saritas et al., 2025); "The goal of foresight is not to predict the future, but to discover the perspectives of many different futures and make decisions today" (Sacio-Szymańska et al., 2016; Barrett et al., 2021 and O'Mahony et al., 2024). Other academics argue that foresight is "a systematic approach to generate future predictions for planning and management by drawing upon analytical and predictive tools to understand the past and present, while providing insights about the future" (Saritas et al., 2017; Hines Andy, 2020; Piirainen and Gonzalez, 2015; Ednie et al., 2022). The pace of change is faster than ever, we posit that 'competitive foresight' analysis considers past and present events, macro trends and technological capability over time to imagine and estimate change and subsequently to define feasible paths from the present to a competitive desired state as part of a sustainable future. Taking into consideration the above, 'competitive foresight' will enable operations managers to integrate anticipatory competitive incremental change and anticipatory competitive radical change. To substantiate this by an example, "If Kodak, once a pioneer in photography, had foreseen and considered in its business strategy the then emerging digital photography, probably it would have defended its strong market position, rather than filing for bankruptcy" (Lucas and Goh, 2009).

The primary objective of 'competitive foresight' is to combines both quantitative forecasting and conceptual frameworks to improve competitive decision-making today, by accurately anticipating the future change with a high level of fidelity. There are two key propositions related to competitive foresight:

(1) Create competitive anticipatory management capability - activating future-oriented interests and concerns encompassing long-term as well as near-term considerations.
(2) Enable operations managers to make prudent anticipatory competitive innovative decisions - Establish new coordinating mechanisms to enable anticipatory well-informed competitive decisions that would otherwise not be possible.

In order for manufacturing firms to switch to competitive foresight to build resilience and adaptability to sustain the business future, the practical implication of competitive foresight is that basic elements of anticipatory and systemic thinking need to be incorporated in the developmental programs of operations managers to prevail over the current dominating responsive routines approach. The common foresight method is summarized in three steps – "Trend and megatrend analysis, Scenario planning, and Visioning and backcasting" as suggested by Saritas et al. (2022) and Barrett et al. (2021). Briefly, trend and megatrend analysis explore "how potential drivers of change have developed over time and how the trend may develop in the future". Scenario planning examines "different patterns of interactions between the key drivers of change and highlights the indirect effects of trends arising from feedback within systems". Finally, Visioning and backcasting defines "a desired future state and then work backward to define feasible paths from the present to that desired state".

Limitations and further research

This research is based on theoretical review of key theories in operations management and empirical data from the manufacturing firms in one country only. Even though the study uses a longitudinal approach which is ideal to test the propositions in this research; it would be of interest to test this theory in many countries. Productivity is a key metric for manufacturing firms; the literature highlights that ultimately competition dictates the choice to compete on few or multiple performance factors. It would be of interest to factor in competition in the statistical analysis, unfortunately the database does not include competition. In addition, firms were not splitted in terms of the ones who are under trade-off and cumulative capabilities. This could have provided more insight regarding the theory of polarity.

CONCLUSION

The reflection on key theories in operations management has highlighted pairs of core drivers and revealed that there is an attribute polarity. The literature review of pairs of core drivers (Location and Profitability, Flow and Productivity, Skills and Competitivity, Performance and Competitivity, Waste elimination and Productivity, Design and Performance) provides substantial support to the theory of polarity. The results of the longitudinal empirical analysis support the proposed theory of polarity. The combination of correlation and regression analysis results reveal that, practically, operations managers instead of "either/or" choice they take "both/end" approach when facing with polarity. The literature has however highlighted the likelihood of manufacturing firms engaging in "either/or" approach based on impact of competition and the scenarios when a specific behaviour may be required or might prevail. An interesting theoretical implication of the theory of polarity is that operations management involves a feedback mechanism from Industrial Engineering to Social Sciences. In view of the competition faced in business environment, the rapidly evolving business environments, and the slowly evolving internal resources of manufacturing firms, competitive foresight has been identified as the missing link. The practical implication of competitive foresight is that basic elements of anticipatory and systemic thinking need to be incorporated in the developmental programs of operations managers to prevail over the current dominating responsive routines approach.

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