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Traditional vs Additive Manufacturing Supply Chain Configurations: A Comparative Case Study

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Abstract

With the recent emergence of Additive Manufacturing (AM) for end-use production applications, contemporary AM management literature suggests radical structural transformations to Supply Chain (SC) structures with corresponding performance benefits, relative to Traditional Manufacturing (TM). However understanding is lacking about the nature of these changes. This paper analyzes the potential impacts of AM processes on traditional SC structures. Configuration theory, postulated by Alfred Chandler and widely applied in studies of TM and service SCs, serves as a basis to analyze the potential impacts of AM on the structural dimensions of SCs, with respect to a set of performance objectives. A framework is developed to capture these impacts with corresponding implications for the operations of part suppliers, module suppliers and final assemblers, deploying AM in different modes and levels in the product hierarchy. By highlighting the differences in characteristics of SCs from TM and AM production scenarios, the framework aids to conceptualize and explain the potential impacts of AM on SC configurations. This differentiation is necessary to understand the relative capabilities of TM and AM SC configurations and implications for different SC entities.

Keywords: Additive Manufacturing; Traditional Manufacturing; Supply Chain Configuration

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1. Introduction

Traditional manufacturing processes falling into two main categories namely formative (injection moulding, die casting etc.) and subtractive (milling, grinding, CNC machining etc.) have dominated manufacturing activities in SCs for decades. Manufacturers deploying these processes rely on scale economies because of the use of expensive dedicated production tools for the fabrication of identical parts, which constrains them to large batches to amortize the cost of tooling investment [1]. This usually results in high physical and market mediating costs along the SC, especially in instances of uncertain demand. Further, scale-economies inhibits the mobility of production facilities because of capacity utilization constraints**.** Lastly, the complexity of products in terms of number of parts and modules increases the layers of production in the SC presenting co-ordination challenges for assembly operations. Altogether these factors increase the geographical dispersion of production activities and ultimately, the distance from market locations, resulting in extended delivery lead-times and inefficiencies related to demand forecasting and capacity scheduling [2]. This creates a major problem for manufacturers dealing with a large variety of products. In essence the structural characteristics of TM SCs namely economies of scale, dispersed nature of multiple manufacturing stages and distance from market locations poses a challenge for SCM especially in terms of cost efficiency and responsiveness [3]. These are problems that AM offers solutions to, however implementation levels are significantly lower than TM counterparts. Researchers have predicted significant impacts to SC structures, however implications are far from being understood [4,5]. This research conceptualizes the potential impacts of AM on the structural characteristics of the SC using configuration theory [6]. The rest of the paper is organized as follows. Section 2 introduces SC configuration studies in TM SCs to highlight the salient dimensions discussed and operational capabilities of AM. Section 3 articulates the research objectives. Section 4 analyses the potential impact of AM on SC configuration dimensions from AM management literature. Section 5 presents a framework to explain the implications for different SC entities. Section 6 summarizes the discussion. Section 7 is the conclusion and agenda for future research.

2. Literature review

2.1. Traditional manufacturing supply chain configurations

Some studies [7–9] have investigated the structural characteristics of TM SCs, with respect to competitive priorities such as efficiency and responsiveness. Such studies are rooted in the theory of configuration with the thesis of alignment between elements of market strategy and elements of organizational structure, postulated by Alfred Chandler [1]. Research in this area focuses on developing typologies and taxonomies that map elements of organizational strategy to elements of organizational structure. This is based on the fundamental assumption that elements of strategy, structure and environment often converge into a tractable number of common, predictively useful archetypes that describe a significant proportion of high-performing firms [10]. From an operations perspective, the elements of strategy correspond to the competitive priorities recognized as critical to a firm's success in the market place; the elements of environment correspond to the characteristics of the markets that a firm operates in and the elements of structure correspond to the operations resources, within and beyond the boundaries of a firm in a SC.

Fisher's seminal work created a strategy-structure typology for TM SCs based on the demand characteristics of functional and innovative products. For example, Innovative product SCs focus on responsiveness because of unpredictable demand, short lifecycles and high profit margins, by deploying inventory and capacity buffers in the SC [7]. A typology combining, lean and agile philosophies was developed, employing lean principles such as waste elimination upstream of the SC, and agile strategies downstream by decoupling inventories [8]. Fisher's work was extended to include supply-side uncertainties, creating four typologies with similar objectives [9]. The level of stock holding centralization and transportation modes required for products based on product-value-density (PVD) and throughput [10]. Fisher's model was also extended to include Replenishment Lead Time (RLT), creating four typologies [11]. Collectively, these studies highlight the critical structural SC dimensions with respect to the most cited competitive priorities, efficiency and responsiveness, accounting for contextual elements such as product demand and supply characteristics. These structural dimensions have been consolidated by researchers under five headings namely: Supply chain structure; Material and information flow between and within key unit operations; the role, inter-relationships and governance between key network partners and value structure of product or service [12]. These structural SC dimensions are expected to be significantly affected by the deployment of AM in manufacturing and service operations, however the nature of this impact is not yet fully understood [5,13].

2.2. Capabilities of additive manufacturing

The technical capabilities of AM for the fabrication of end-use parts are well known in literature with empirical examples. For instance, production of complex geometries for lattice and honeycomb structures, internal cooling channels, overall serving to produce lightweight components that are critical in sectors such as aerospace and automotive. Consolidation of several parts in an assembly into one also reduces part failure rate because of fewer number of potential failure points in joints. On the other hand, there are non-technical or operational capabilities of AM that have mostly been captured by the conceptual literature. The most fundamental of such capabilities is tool-elimination, which makes it possible for the economical production of parts in smaller batches, potentially enabling the distribution of production capacity close to customer locations, reducing lead-time. Secondly, the additive layer process reduces waste in comparison to subtractive TM processes and raw materials are recyclable, which improves the efficiency of materials management. Thirdly, the On-demand capability of AM means that less capital is tied up in inventory, thereby freeing up working capital for other aspects of the operation [14]. Also, inventory obsolescence and part shortages could potentially be reduced [15] . Lastly, the capability of AM to combine multiple assembly components into one build operation, known as functional integration or parts consolidation (PC), reduces the burden of changeovers and setups, number of machinists, part count and handling, potentially creating shorter production lead times. These capabilities and benefits are being exploited, to varying degrees, in manufacturing and service SCs and has reawakened the old question of manufacturing process choice, in this case TM or AM, for the production of parts and modules. The manufacturing process represents a primary structural element that determines the characteristics of other secondary elements in a SC. Recent approaches to the manufacturing process choice problem have adopted a narrow perspective, focusing solely on costs and ignoring implications for structural dimensions [16], a similar problem in past approaches to the make-or-buy question [17]. There have been recent calls for more holistic approaches to evaluate the question of whether to use TM or AM and the impact of that decision on SCM [5,13]. The section that follows presents the framework used for this research as a tool to evaluate the manufacturing process choice question, TM or AM, and implications for traditional supply structures with respect to a set of competitive priorities and market characteristics, from the AM management literature

3. Research Objectives

To address the criticism associated with the narrow cost perspective on manufacturing process choice decisions, this research adapted the holistic framework, developed for the make-or-buy decision [18] for the TM vs AM decision (Fig. 1). The interaction of external and internal elements (elements of environment) activates performance-related triggers (elements of strategy) for the TM vs AM decision. For example, supply risk of legacy parts and batch manufacturing constraints with TM results in high-inventory holding costs thereby increasing inefficiencies in the SC. This increased inefficiency triggers the TM vs AM decision because of the capabilities of AM to reduce inventory holding via tool elimination. Consequently, this decision (TM vs AM) has implications for the strategic SC configuration dimensions (elements of structure) namely Supply chain structure, Material and information flow between and within key unit operations, Role, inter-relationships and governance between key network partners, Value structure of product or service and associated factors. The dimensions, “Information flow” and “relationship between key partners” are combined for ease of discussion. Performance measures (elements of strategy) such as inventory turnover are used to evaluate the level of achievement of the target levels set by the performance related-triggers, inefficiency in this case. The arrows pointing out from the performance measures indicate that the manufacturing process choice is not a static decision as elements in the environment can change, necessitating a re-evaluation of the decision. This paper has two main objectives. 1 understand how the performance-related triggers and other contextual factors affect the structural characteristics of TM and AM SCs. 2 conceptualize the potential impact of AM on traditional SC structures.

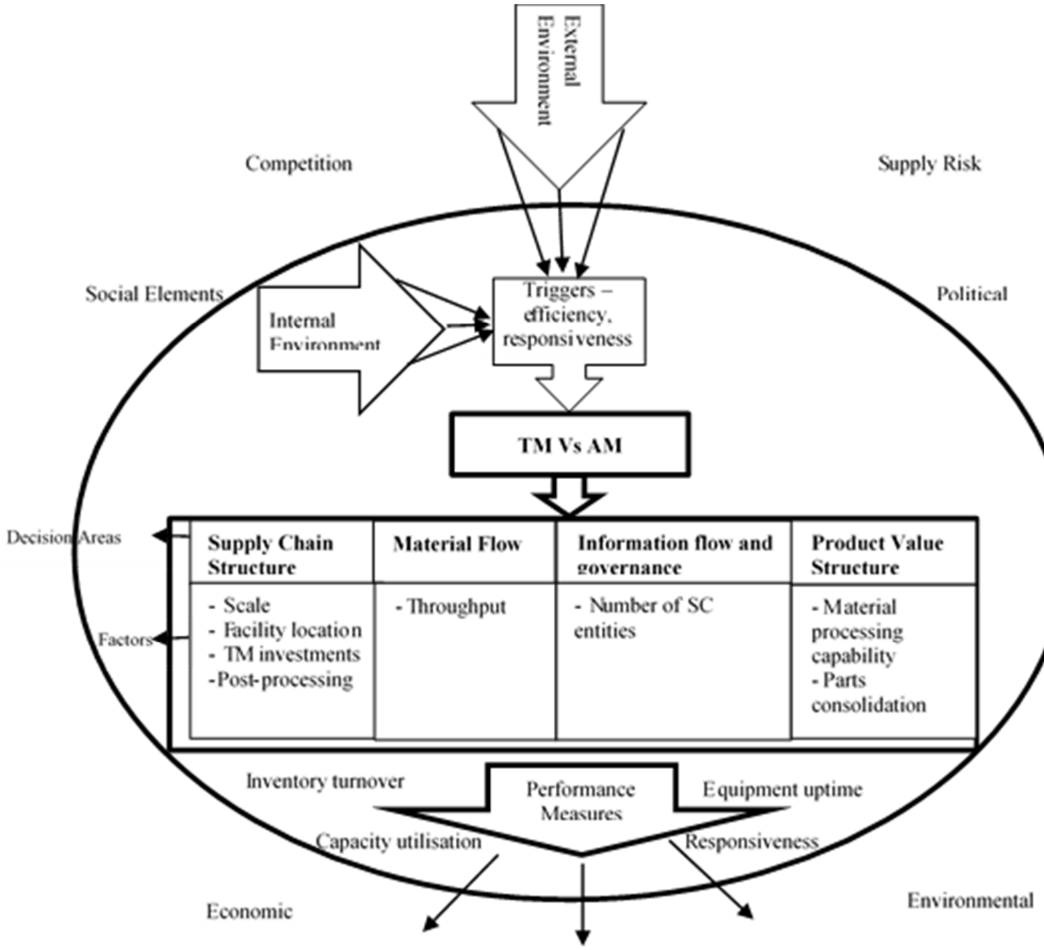

Figure 1: Adapted Manufacturing Process Decision Framework from [18]

4. Potential effects of additive manufacturing processes on traditional supply chain structures

The structure of TM SCs as determined by elements of environment and strategy have been discussed earlier (Section 2.1). The non-technical capabilities of AM have also been enumerated (Section 2.2). This section presents the potential implications of the capabilities of AM on the dimensions of traditional SC structures as suggested by the AM management literature. Implications for part, module suppliers and final assemblers will be presented subsequently.

4.1. Supply chain structure

The presence of expensive dedicated tools constrains manufacturers to large batches to amortize the cost of tooling investment [1] putting specialised suppliers in a privileged position to leverage scale and specialisation economies in design, tooling, change-over and ramp up costs over large production volumes thereby reducing unit costs of components [4,5,18]. Furthermore, the complicated nature of TM machine tools creates challenges for non-specialists [19]. By making fabrication of small batches of parts economical and removing the complications of operating TM machines, AM potentially enables the participation of SC entities further downstream, who do not possess the scale of low-cost suppliers, to vertically integrate the production of parts in-house, albeit with the potential for lower capacity utilisation. That said, capacity utilisation can be enhanced with AM’s capability known as “Fungibility”, which enables part substitution whereby identical and non-identical parts can be produced in one build [16]. However, challenges exist with scalability in terms of build envelope size and speed, as sets of parts with varying sizes cannot simply be scaled up without redesigning the build envelope. Further, non-specialised part suppliers can boost AM capacity utilisation by providing commoditized services to external customers [2]. In the spare parts SC, low demand volumes may weaken the bargaining power of OEMs against suppliers, serving as an additional incentive to deploy AM capacity in-house, especially where supply options are limited. On the other hand, AM could also decrease the dependence of small specialised suppliers on particular customers, due to elimination of largescale investments in costly production runs tailored to one buyer, for TM processes. With all these considerations, OEMs must also consider when to switch back to TM to leverage the economies of scale of specialised suppliers at higher volumes, however the feasibility of part redesign also has to be considered [5]. For specialised suppliers heavily invested in TM, established markets may control its resources against investments in AM , especially when demand for AM parts is not significant [20]. Capacity utilisation is highly dependent on the number of parts that can be digitally manufactured [15]. Further, AM capacity utilisation decreases with decreasing distances of production facilities to market locations in the order of centralised configuration with the highest capacity utilisation potential, hub configuration with an intermediate level and distributed with the lowest level and least economical [21]. Additionally, the distributed configuration for AM has been criticised as being infeasible because of dependence on scale economies from skilled operators and sophisticated equipment to produce durable parts. Localisation of AM capacity depends on an established customer base and a sound understanding of market demand and near net-shape production quality of parts. Requirements of post processing (e.g. heat treatment, support removal) and supporting TM technology, such as CNC, restrict the scope to localise AM capacity because they operate with economies of scale [22].

4.2. Material flow within and between key unit operations

For specialized TM part suppliers, AM could be deployed to improve process efficiency in that parts with low and sporadic volume can be allocated to AM, thereby reducing setup and changeover on TM production lines [3]. This type of process configuration has been conceptualized as “Combinational”, in line with the accepted view of the complementary role that AM will play with TM [24]. This will be particularly applicable to firms using jobbing or batching processes where AM is expected to be effective in reducing the number of TM steps, eliminating scrap, material movement, work-in-process inventories and defects – process savings [25]. For example process-savings have been achieved for a filter manufacturer [26]. The TM process involved two machining operations, before finishing, testing and packaging and parts were made-to-stock. With AM, barring design activities with the customer, the actual production process was the printing operation and parts were made to order, effectively reducing work in progress and finished goods inventory.

Economic fabrication of smaller batches could potentially enable postponement and localization of production and creation of variety at the point of use [4,16] effectively shifting the order decoupling point to the customers location, thereby enabling responsiveness. This is an added incentive for SC entities, without the scale of specialized suppliers, to deploy the technology for the fabrication of a variety of parts for their production lines. For OEMs, fabrication of parts formerly handled by external suppliers can be localized within assembly plants and spare parts production can be redistributed closer to customer locations promoting efficiency in terms of reduced inventory holding, part shortages, material handling and transportation costs. Problems associated with line balancing, capacity management and bottle necks can be virtually eliminated. Further these assemblers deploying AM on the shop floor could also eliminate just-in-time co-ordination efforts from suppliers [4], significantly reducing transportation costs in the long-run [5]. In essence, a lot of waste is eliminated, promoting a lean operation [25]. However, the speed and throughput of the AM processes must be assessed in relation to demand rates as studies show that the throughput of AM systems are significantly lower than TM.

4.3. Information flow and relationship between key partners

By shrinking the SC distance and fabricating parts at the point of use, AM could potentially reduce the errors associated with demand planning and forecasting as the number of SC entities involved is reduced. This also leads to increased levels of collaboration between SC entities, especially in terms of knowledge dependency for design activities between OEMs and AM suppliers [23]. As control information required to fabricate a part is embedded in the digital design, this is likely to reduce scheduling and planning requirements for assemblers [6]. Further, the removal of intermediaries in the SC with electronic commerce solutions for AM, is also expected to create better demand visibility, which in turn aids capacity optimization and production planning. The customer also increasingly becomes a stronger member of the SC in relation to its suppliers through co-creation, as such the relationship link becomes stronger. Also, shifting production closer to point of use also enables improved decision making based on more accurate information from local conditions [20].

4.4. Value structure of the product

The success of implementing AM for postponement in manufacturing and service SCs depends on reengineering existing TM parts, new products for AM and alignment with SC design. TM is governed by design for manufacturing (DFM) rules which places constraints on designs because of manufacturability requirements determined by the degrees-of-freedom in the manufacturing process. Increasing complexities of part design also causes corresponding increases in production process costs for TM (e.g. CNC machines) as more axes in machines must be built in to accommodate complex design patterns. Products are usually divided up into modules, with a trade-off on performance, forming the basis of supplier selections based on parts and modules with similar materials. These parts and modules, produced by different suppliers, are assembled in the manufacturing plant of the OEM, requiring a high degree of SC integration so that products are delivered in the right quantities at the right times. Product structures with a large number of materials tend to have complicated SC structures with many tiers that cross organizational and national boundaries, increasing co-ordination requirements such as just in time, lean manufacturing and advance shipment notices [3]. Further, various stages of the SCs of multinational corporations have been outsourced to more cost-effective locations in emerging and developing economies, effectively increasing the dispersion of key operations and requirements for co-ordination and transportation [19]. AM breaks barriers between integral and modular architectures to enhance production efficiency, however coupled with post-processing issues [27]. PC , recognized as one of the most significant capabilities of AM [6], reduces the part count, which essentially reduces the number of value adding activities within and between unit operations in a SC, effectively shortening process chains, reducing lead time [3,28]. A notable example in the aerospace industry is that of the fuel nozzle produced by GE aviation where the part count was reduced from 18 to 1. The impact of PC on the structure of the SC is expected to be significant, however the extent depends on the level of the product at which consolidation is achieved in the overall product structure (i.e. component, subassembly, final assembly) and also the supply chain entity that deploys the AM technology.

At the level of part consisting of smaller components within the boundaries of a module, possibly of the same material and fabricated in the same processing plant, the effect of PC is confined to a process saving, reducing the number of manufacturing and assembly operations to fabricate a part. For hearing aid shell fabrication, manual TM production steps namely sculpting, molding, and curing are compressed into two steps with AM namely printing and grinding [21]. For the specialized supplier, who deploys AM in-house, the impact of this process-saving is likely to be evident and more significant as they perform job-shop operations in-house [25]. For the component assembler, vertically integrating the production of a part with AM in-house, it is likely to be a supply chain saving in terms of reducing coordination efforts with specialized suppliers and transportation costs [4]. At the level of the module, containing a number of parts (with similar or different materials) from different suppliers, AM is likely to bring a process saving for the component assembler in that a lot of steps associated with traditional assembly operations will be eliminated [6]. There will also be a SC saving from elimination of the co-ordination efforts and transportation costs from sourcing parts from external specialized suppliers, a similar benefit for the final assembler [4]. At the level of the final assembly, involving several modules, AM is likely to bring a process saving for the final assembler in that hitherto TM assembly operations involving several steps can be reduced with AM fabricating complex products with different types of materials. Similar to the benefits from the module assembler, a SC saving is also expected. The level of sophistication of the AM process must be on a higher level in terms of its ability to process a higher number of materials than the level of the module. This will effectively collapse the tier structure of traditional SCs reducing the production of complex products to significantly fewer stages. This has also been referred to as the supercenter capable of producing an array of low-volume products, containing no asset specificity and, in theory, zero change-over costs [3].

5. Traditional vs additive manufacturing supply chain configuration framework

The preceding section examined potential impacts of AM on traditional SC structures. Based on that discussion, this section presents a framework that captures these potential impacts and implications for members of a three-echelon manufacturing SC consisting of part and module suppliers, and final product assemblers. These implications have been presented in a matrix (Fig. 2), the horizontal axis representing the SC entities (part and module supplier, and final assembler) arranged in sequence, typifying a scenario were two parts are assembled by the module supplier, and in turn, two modules are assembled by the final assembler. The focus of the framework is on the in-house manufacturing and assembly operations of a part supplier (representing part A), a module supplier (representing module A) and a final assembler (representing product A). The vertical axis represents three production scenarios for each of the SC entities. Scenario one represents AM part production in-house for each of the SC entities. Parts and module suppliers, and final assemblers can deploy AM in-house for parts fabrication with different implications for their assembly operations. Scenario two represents module production with AM, where part suppliers are exempt and module suppliers deploy AM to combine previously assembled parts into one module in a build. In scenario 3, the final assembler deploys AM to make a final product. Following is a discussion potential implications of AM deployment for the operations of each of the SC entities.

5.1 Part suppliers

Committed investments in TM technologies by part suppliers has been cited as a barrier to investment in AM, especially in instances where volumes are not significant to justify capacity deployment [5]. That said, there are potential benefits for the deployment of AM in their manufacturing operations. Firstly, they can deploy AM in standalone mode for the fabrication of low volume parts [24]. In comparison to TM process, AM reduces the number of unit machining processes and assembly required to fabricate a part. For example, the reduction three steps involved in fabricating a blower component namely (turning, CNC machining and assembly) to one build operation in the AM machine, albeit ignoring post-processing activities [17]. This increases the efficiency of the operation in terms of waste elimination from setups, changeovers, material movement and usage; and work in process inventory reduction [25] albeit with significantly less throughput than TM counterparts for some applications [29]. Here, PC is achieved at the level of the part, within the boundaries of one-unit operation in the SC (Section 4.4). Due to Economies-of-one and Fungibility, AM could also potentially increase the flexibility of part suppliers in accommodating orders of varying small volumes from their customers, without cost penalties [30]. AM can also be deployed in "Combinational mode" [24] to absorb low volume orders from TM lines to increase efficiency [27]. Further efficiencies can be created through economies of specialization as the suppliers improve competencies in managing AM, pooling demand from existing and new customer segments to optimize capacity utilization [3,19], for which centralization may be necessary. The use of e-commerce platforms could be used by suppliers to generate orders to fill up build envelopes with the aid of packing algorithms, promoting efficiencies in capacity utilization. To summarize, the deployment of AM by a part supplier in standalone or combinational mode could potentially generate efficiencies, speed and flexibilities within the confines of a manufacturing plant amounting to process-savings. This position is represented by cell "A" in Fig. 2. It represents a scenario where the part in question is completely fabricated by AM, most likely with the same material, to realize the process savings described above, hence "AM assembly". The two cells below marked "x" are not applicable because the part supplier lacks the competence to produce modules and final products

5.2 Module suppliers

Cell "B" in Fig. 2 is labelled "Traditional module assembly" as AM is deployed by the module supplier to fabricate parts that will be traditionally assembled with other parts to build the module. This is a combinational configuration where AM coexists alongside TM processes to manufacture a module [24]. Similar to the part supplier, the AM equipment in this scenario is likely to be capable of processing single materials for part production. Therefore, some parts that were formerly sourced from an external supplier (for e.g. Part "A") to produce a module are brought in-house and fabricated with AM. This translates to vertical integration of parts production by the module supplier, which could be beneficial for small volumes, because low-volumes weaken bargaining powers in negotiating volume discounts. Similar to part suppliers, capacity utilization of AM can be enhanced by offering commoditized services to external customers to fill up the build envelope [3]. In this scenario PC is achieved at the level of the part (Section 4.4), hence it does not translate to significant process savings in relation to the traditional assembly operation. Process savings result from a reduction in inventory holding and obsolescence costs from holding excess finished parts emanating from bulky orders from external suppliers, caused by batching constraints. Significant SC-savings will be realized for the module supplier as there is a reduction in the transportation and co-ordination requirements, associated with sourcing parts externally, for assembly [6]. In cell "D", the module supplier deploys AM in-house for the production of module "A" in one build operation, the "Standalone" mode [24], hence the labelling "AM Assembly". In this scenario, an integral product design, cutting across boundaries of separate parts formerly sourced from different suppliers, with the same or possibly different materials is employed, achieving part consolidation at the level of the module [27]. A well-documented example is the GE 3D printed Fuel Nozzle, which originally consisted of 18 different parts that were sourced from different vendors and assembled. The AM version, printed with a nickel alloy, reduced the part count from 18 to 1 with superior performance in terms of lightweight and durability. In this scenario, the parts echelon is eliminated totally (depicted by the adjoining cell marked x in the part supplier column), bringing a significant SC saving in terms of transportation costs, inventory holding and co-ordination of parts from suppliers for the traditional assembly operation. Further, errors associated with demand planning and forecasting of parts are bound to reduce because of the elimination of the parts supplier's echelon, effectively shortening the SC. In addition, the module supplier also makes a process saving compared to the traditional assembly operation.

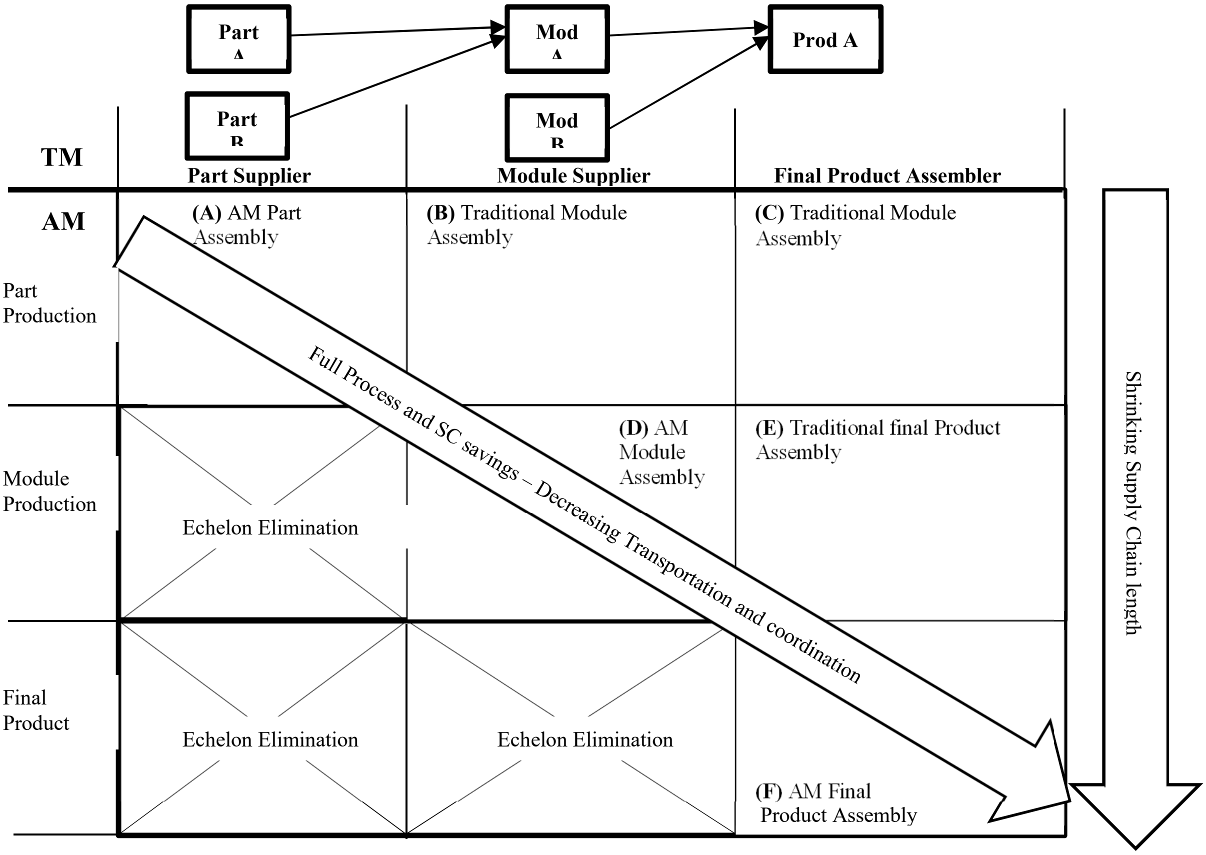

Figure 2: Traditional vs Additive Supply Chain Configuration Framework. Source (Authors)

5.3 Final product assembler

In cells “C” and “E”, the final assembler deploys AM in combinational mode for the production of parts and modules, previously sourced from external suppliers [24]. SC and process-saving is achieved in terms of the elimination of logistics and co-ordination burdens and inventory related costs to promote efficiency. AM capacity utilization can also be boosted by providing commoditized services to other business units or external customers to fill up the build envelope [30]. In the most extreme case of PC, cell “F”, were consolidation is achieved at the level of the final product (inter-module), the operation experiences full SC and process savings emanating from the eliminating in-bound flows for the traditional assembly operation. In this scenario, the capabilities of the AM equipment must be very sophisticated in multiple material processing, where research is ongoing to combine different materials in the same build envelope, however constraints exist in material combinations.

6. Discussion

Discussions in the preceding section indicate that the performance benefits derived from the deployment of AM depend on several factors such as the SC entity, the mode it is deployed and the level at which PC is achieved. For the part supplier, efficiencies can be generated in both standalone and combinational modes through waste elimination; flexibility of the AM build envelope could increase responsiveness, all achieved within the confines of a single manufacturing plant, amounting to a “Full process-saving”, compared to the TM operation with several steps and assembly (Cell A). For the module supplier, “Full process and SC-savings” are achieved when AM, in standalone mode, achieves PC at the module level, replacing the traditional assembly process with an AM build, eliminating in-bound flows of parts inventory from suppliers (Cell D). Partial process and SC savings are achieved when AM is deployed in combinational mode, to make parts as the traditional assembly operation and in-bound flows of parts from suppliers still exist (Cell B). For the final assembler, full process and SC savings are achieved when PC is achieved at the level of the final product with AM in standalone mode (Cell F). Partial process and SC savings are achieved when AM is used for part and module production (Cells C & E). In essence, operations along the diagonal of Fig. 2, deploying AM in standalone mode for the production of parts, modules and final products respectively achieve a full-process and SC savings compared to their traditional assembly counterparts, the exception being the part supplier where SC savings do not apply. These operations are likely to excel in the production of low volume parts and modules, with the flexibility to accommodate varying order volumes from customers; efficient in terms of waste elimination from multiple processing steps, reduced work-in-process stock, improved working capital management and reduced transportation costs. Efforts rather will be directed towards the management of raw materials, which reduces finished parts inventory risk. Other operations are likely to excel at a lesser degree on these performance dimensions, because of the presence of TM elements. In addition, the length of the SC decreases with increases in the level at which part consolidation is achieved in the product structure, from parts to modules and the final assembly.

7. Conclusion

This paper presented an initial framework (Fig. 1), illustrating the dynamics of interaction between elements of environment, strategy and structure for the manufacturing process choice decision. Subsequently, a framework was derived (Fig. 2), illustrating the implications of the decision on the strategic SC configuration dimensions and implications for process and SC performance for suppliers and assemblers. Further, the application of AM in different modes was demonstrated with corresponding performance benefits for the different SC entities involved in manufacturing a product. Six deployment strategies were analyzed with indications of values for performance dimensions on the process and SC level. This paper contributes to AM management by taking a more holistic and qualitative perspective on the manufacturing process choice decision, a departure from narrow cost perspectives prevalent in AM management literature. Further SC configuration theory, prevalent in TM SCs was extended to the realm of AM to assess the potential impacts, a seminal contribution to the AM management literature. Further, this paper contributes to the delineation of AM capabilities on different levels of the product structure, a departure from generic approaches in the literature. The limitations of this paper must be acknowledged. This paper is conceptual, and its propositions need empirical testing, especially considering the process limitations of AM in terms of speed, throughput and quality. Firstly, practicalities and limitations of each of the deployment scenarios must be set out to guide AM implementation decisions. This will further serve to provide evidence of successes to enable the diffusion and legitimatization of the technology [25]. Secondly, actual performance levels of operations in process and SC savings need to be measured empirically in application sectors such as automotive and aerospace. Case studies, carrying out performance measurement comparisons between AM and TM should be carried out to measure performance gaps [4] in each of the deployment strategies presented.

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