Proceedings of the International Conference on Industrial Engineering and Operations Management
Paris, France, July 26-27, 2018

Strategic Alignment of Information Systems Flexibility with Organization's Operational and Manufacturing Philosophy: Developing a Theoretical Framework

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Abstract

Information systems (IS) forms the nucleus of any organization. Proper coordination, timely support and availability of information is essential for any organization to function properly in order to achieve its objectives, fulfill its strategic needs and sustain in the competitive environment of uncertainty. Strategic information system (SIS) is the new term adhering to the above concept which talks about alignment of information needs to strategic orientation of any organization. In this paper, we particularly talk about the various manufacturing strategies adopted by organizations and try to relate their characteristics to the type of IS flexibility requirement to effectively support them. A literature review has been presented to identify the diverse organizational strategies and IS flexibility dimensions. Based on the review, arguments are made to build the theoretical framework and subsequent hypothesis.

Keywords
Strategic Information Systems, IS flexibility, Manufacturing Strategies

1. Introduction

Organization's operating strategy must be supported simultaneously by all related functions and systems functioning within the enterprise. IS forms an integral part of any organization to manage the information requirements. The current business environment is characterised by fast changing and competitive conditions which requires flexibility in IS to match and support the strategic needs. This paper identifies some major strategic groups and tries to map them to the type of IS flexibility suited for them.

2. Literature Review

2.1 Literature review on organizational strategy

Many researchers made attempts to understand the operating behavior of different types of organization and classify them accordingly into various strategic groups. The first such classification of organizational strategy was given by Miles et al. (1978). Their typology was based on the changing rate of products and market. They divided organizations into three types namely defender, prospector and analyzer. Defenders are the stable form of organization with limited product range, covering a narrow segment of the total market. They compete on cost, offering the best product at the lowest price in the market. Prospectors continuously look for market opportunities by introducing additional features into the existing products as per customer demand. These organizations maintain industry leadership in product innovation by emphasizing more on marketing and R&D functions. The third strategic group i.e. Analyzer lies in between defender and prospector strategy. These organizations concentrate on limited product ranges maintaining quality standards. At the same time, they also excel in delivery of new products by avoiding excessive risks. Porter (1980) classified the organizations into three prominent strategic groups namely cost leadership, differentiation and focus based on competitive advantage. Organizations following cost leadership strategy offer lowest price in the industry by utilizing technological efficiency and economies of scale.

Organizations pursuing differentiation strategy focus on customer requirements and accordingly implement differentiating features within the existing products. Focus type organizations follow a mixed operating strategy and dedicate a poorly served market segment. Several other authors i.e. Miller and Friesen (1982), Gupta and Govindarajan (1982), Miller and Roth (1994), Smith (1997) made prominent attempts to understand the organizational strategy. On examining the subsequent studies, it is found that broadly three types of strategic groups gained prominence. The strategic typology suggested by Miles et al. (1978), Porter (1980) and Miller and Roth (1994) namely defenders or cost leadership, prospectors or differentiators and innovators is exhaustively used to classify the different manufacturing organizations based on their operating strategy. Hence our study and research framework takes these three strategic types into consideration.

2.2 **Literature review on IS/IT dimensions**

IS flexibility has been conceptualized by various authors in their work. Some of the prominent contributions in the field of IS/IT flexibility has been highlighted in the Table 2.1 given below.

Table 2.1: Literature review on IS/IT flexibility

Authors	Dimensions of IS/IT flexibility
Duncan (1995)	Connectivity, Compatibility and Modularity **(**IT infrastructure flexibility)
Turner (1999)	Connectivity, Compatibility and Modularity
Byrd et al. (2000)	Connectivity, Compatibility, Modularity and IT personnel competency
Schwager et al. (2000)	Connectivity, Compatibility, Modularity and IT personnel
Chung (2005)	Connectivity, Compatibility, Modularity and IT personnel
Chanopas et al. (2006)	Connectivity, Compatibility, Modularity and IT personnel Competency, Scalability, Continuity, Rapidity, Facility and Modernity
Rathje, S.M. and Boyle, T.A. (2012)	System connectivity, Process integration, Hierarchical integration, User customizability and Consistency.
Kumar and Styllianou (2014)	Flexibility in information systems operations (volume flexibility, operating flexibility, input/output flexibility, integration flexibility) Flexibility in information systems and services development and deployment (development flexibility, new technology deployment flexibility) Flexibility in information systems management (financial flexibility, sourcing flexibility, staffing flexibility)

Connectivity is the ability of any technology component to attach to any of the other components inside and outside the organization environment. System connectivity can be thought as an effort such as time, cost and programming required to link the organizations IS to the different specialized systems along the value chain. High levels of this dimension allow organizations to respond to internal changes and uncertainty along the supply chain with limited interruption to users. Compatibility is the ability to share any type of information across any technology component. Modularity is the ability to add, modify and remove any software, hardware or data component of the infrastructure with ease and no major overall effect. IS is not just about hardware/software components but a close coordination between these components with human resources i.e. IT personnel. IT personnel competency can be defined as relevant skills and experiences to effectively perform IT activities. Scalability is defined as the degree to which hardware/software can be scaled and upgraded on existing infrastructure. Continuity is the degree to which hardware/software/data/IT personnel can seamlessly serve the users in an organization without disruption. Rapidity can be defined as the degree to which hardware/software can deliver information whenever it is needed. Facility is the degree to which hardware/software can be used with ease. Modernity may be defined as the degree to which hardware/software are based on well-known products and technological trends. Reconfigurability is the ability to reconfigure computing capability of a system, so that its behavior can be changed to match the current business requirements. Process integration can be considered as the number of upstream and downstream steps that are integrated in the value chain of an organization. Organization's IS major function is to integrate these processes which includes production, supplier management, customer management etc. Process integration flexibility is the

number of steps that can be actually captured by the organizations IS with limited effort in terms of time, cost and programming. Process integration spans along the supply chain. Hierarchical integration helps in presenting data at different levels i.e. from basic delivery to strategic supplier data as well as the ability to consolidate and synthesize the data in different aggregation levels. User customizability is the ability of the end user to customize the system to better carry out the individual business activities without influencing the stability, function and structure of the processes. Consistency addresses how uncertainty impacts the data quality and accuracy remain stable in uncertain conditions is critical for IS.

3. Discussion of Theoretical Research Framework and Hypothesis Building

3.1 Modularity or distributed systems

It is degree to which a system's components can be separated and recombined. Its meaning is more specific with regard to the area in which it is used. In industrial design, modularity refers to an engineering technique that builds larger systems by combining smaller systems. In the manufacturing domain, modularity refers to the use of exchangeable parts or components in fabrication of an object. Within the context of IS/IT, modularity is used or applied in many ways. Modular programming refers to the compartmentalization and inter-relation of the parts of a software package. In the study of networks, modularity refers to a benefit function that measures the quality of division of network or networks into groups or communities. In software design, modularity refers to a logical partitioning of the software design that allows complex software to be manageable for the purpose of implementation and maintenance. The logic behind partitioning may be based on related functions, implementation considerations, data links and other criteria. We refer modularity as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. IS modularity is low for defenders and high for prospectors as organizations pursuing defender strategy will have a more centralized architecture of IS. Information related to product, process, customers, and operations is procured and processed centrally. Hence, decisions relating to strategy, tactical or operational are taken centrally. On the other hand, organizations with prospector strategy is likely to have a distributed or modular IS architecture supporting their strategic orientation and needs.
Hence, we hypothesize:
H1.a Organizations with defender or cost leader strategy have information systems which are low in modularity.
H1.b Organizations with differentiator or prospector strategy have highly modular or distributed information systems.

3.2 IS Integration

System integration may be defined as a process of bringing together the component sub-systems into one single system or an aggregation of subsystems and ensuring that the components or sub systems function together as a single entity delivering the overarching functionality. Within the domain of IS/IT, it is defined as a process of linking together different computing systems and software applications physically or functionally, to act as a coordinated whole. The IS integration can be facilitated utilizing a variety of techniques such as computer networking, enterprise application integration (EAI), business process management (BPM) or manual programming. Enterprise application integration (EAI) utilizes softwares and computer systems' architectural principles to integrate a set of enterprise computer applications. The different types of business softwares such as supply chain management applications, ERP systems, CRM applications for managing customers, business intelligence applications, payroll and human resource management (HRM) systems typically cannot communicate with one another for sharing data or business rules. Business process management (BPM) uses various techniques to discover, model, analyze, improve, optimize and automate the various business processes within an organization. We refer modularity as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. IS integration is high for both defenders and prospectors as both type of organizations will require a highly integrated IS to access resources and valuable information across the various supply chain partners to take informed decisions.
Hence, we hypothesize:
H2.a Organizations with defender or cost leader strategy have information systems which are highly integrated.
H2.b Organizations with differentiator or prospector strategy have information systems which are highly integrated.

3.3 IS Interoperability

Interoperability is the property that allows for the unrestricted sharing of information and resources between different systems. It can also refer to the ability to share data between different components or machines both via hardware and software or it can be defined as the exchange of information and resources between different systems

connected through local area networks/ wide area networks. For two interoperable systems, they must be able to exchange data and subsequently present the data such that it could be understood by the end user. Interoperability is feasible through hardware and software components that conform to open standards. We refer IS interoperability as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. IS interoperability will be high for defenders and low for prospectors as organizations with defender or cost leadership strategy can modify themselves to adjust their strategic needs but prospectors or differentiators work with different kinds of IT/IS systems to match their requirements which are not easily interoperable.

Hence, we hypothesize:

H3.a Organizations with defender or cost leader strategy have information systems which are high in interoperability.

H3.b Organizations with differentiator or prospector strategy have information systems which are low in interoperability.

3.4 Loose coupling

Loose coupling is an approach to interconnecting the components/modules in a system or a network such that these components depend on each other to the least extent practicable. Coupling refers to the direct knowledge that one component has of another within a system. In computing and systems design, a loosely coupled system is one in which each of its components has, or makes use of, little or no knowledge of the definitions of other separate components. It is opposite to tight coupling. Components in a loosely coupled system can be replaced with alternative implementations that provide the same services. At the same time, loosely coupled systems are less constrained to the same platform, language, operating system, or build environment. The goal of loose coupling architecture is to reduce risk that a change made in one component will create unanticipated changes within other components. A loosely coupled system can be easily broken down into definable components. The extent of coupling in a system can be measured by mapping the maximum number of element changes that can occur without adverse effects. Loose coupling is an architectural principle and design goal in service oriented architectures. Loose coupling in a way promotes system reusability. We refer loose coupling as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. Loose coupling as a characteristic feature of IS will be high for defenders and low for prospectors.

Hence, we hypothesize:

H4.a Organizations with defender or cost leader strategy have information systems which are low in loose coupling characteristics.

H4.b Organizations with differentiator or prospector strategy have information systems which are high in loose coupling characteristics.

3.5 Scalability

It is the capability of a system, network or process to handle a growing amount of work or its potential to be enlarged to accommodate that growth within the existing system. A system is considered scalable if it is capable of increasing its total output performance under an increased load when resources are added. It is a highly significant issue in electronic systems, databases and networking. A system whose performance improves after adding hardware/software resources, proportionally to the capacity added, is said to be a scalable system. An algorithm, design, networking protocol, or program is said to scale if it is efficient and practical when applied to large situations such as large input data set, a large number of outputs or users or a large number of participating nodes in a distributed system. On the other hand, if the design or system fails when a quantity increases, it is not scalable. The concept of scalability is technology as well as business settings i.e. the ability for a business or technology to accept increased volume without impacting the contribution margin.

Scalability can be measured in various dimensions. Administrative scalability refers to an ability for an increasing number of organizations or users to easily share a single distributed system. Functional scalability is the ability to enhance or upgrade the system by adding new functionality at minimal effort and time. Geographic scalability is the ability to maintain performance, usefulness or usability regardless of expansion from concentration in a local area to a more distributed geographic pattern. Load scalability refers to the ability for a distributed system to easily expand and contract resource pool to accommodate heavier loads or input loads. It refers to the ease with which a system or a component can be modified, added or removed to accommodate changes in load. Generation scalability refers to ability of a system to scale up by using new generation of components. Heterogeneous scalability is ability to use/synchronize components of different vendors. We refer scalability as a flexibility dimension of IS/IT systems

and relate it to organization's operational and manufacturing strategy. Scalability of IS will be high for defenders and will be low for prospectors as IS/IT systems lends support to different modules incrementally or in batches as per modifications or requirements

Hence, we hypothesize:

H5.a Organizations with defender or cost leader strategy will acquire information systems which are high in scalability to satisfy their strategic requirements by making huge investments.

H5.b Organizations with differentiator or prospector strategy have information systems which are low in scalability.

3.6 Continuity

It is the degree to which hardware/software/data/IT personnel can seamlessly serve the users in an organization without disruption. IS/IT continuity is a holistic approach to managing technology systems in the event of a major disruption. The organization's IT functions that are essential for business continuity should be identified and apportion available budget accordingly so that failover mechanisms can be put in place. For proper handling of situation during any such disruption, a set of policies and procedures must be formulated ahead of time. IS continuity plans should be concise. Improving upon IS continuity is an organization wide endeavor to which organization has to be committed. IS continuity harness technologies to improve business continuity. The three major phases of IS continuity process are preparing for IS incidents, coping and mitigating the impact of IS incidents and recovering from IS incidents. We refer IS continuity as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. IS continuity will be high for defenders as well as prospectors to access resources and valuable information across the various supply chain partners to take informed decisions. On the other hand Innovators will have low IS continuity compared to defenders and prospectors owing to discontinuous innovative changes in production design

Hence we hypothesize:

H6.a Organizations with defender/cost leadership or differentiator/prospector strategy have information systems which are highly continuous.

H6.b Organizations with innovator strategy have information systems which are low in continuity as compared to defenders and prospectors.

3.7 Compatibility

Compatibility is defined as the capacity for two systems to work together without having to be altered or modified to do so. Compatible software applications use the same data formats. Within the IS arena, compatibility refers to a situation when different systems, system components or system activities operate in harmony i.e. can communicate effectively or exchange records with minimum of effort. In other words, compatibility implies the ability of different entities to work in combination. Systems are considered compatible when the results of processing in one system are immediately and directly usable by other organizations having similar but not necessarily identical systems. The principal reason for seeking compatibility is to facilitate cooperation or resource sharing among organizations. Compatibility is closely related to standardization. The more organizations adhere to common standards, the more likely it is that there is/IT activities and outputs will be compatible. Compatibility is also related to consistency. A major reason for seeking compatibility is to allow interconnection of various systems and networks. We refer IS compatibility as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. IS compatibility will be high for defenders as most of the IS/IT components are fixed and acquired altogether. On the other hand, prospectors will have more issues related to incompatibility of IS/IT systems as new components/modules are added incrementally as per strategic requirements.

Hence, we hypothesize:

H7.a Organizations with defender or cost leader strategy have information systems which are high in compatibility.

H7.b Organizations with differentiator or prospector strategy have information systems which are low in compatibility.

3.8 Connectivity

Connectivity is the ability of any technology component to attach to any of the other components inside and outside the organization environment. In other words, it is the measure of the extent to which components (nodes) of a network are connected to one another and the ease (speed) with which they can converse. It is used to describe how well hardware or software devices can communicate with a range of other devices. We refer IS connectivity as a

flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. Organizations with either a defender or prospector strategy will require a highly connected information system to access resources and valuable information across the various supply chain partners to take informed decisions.
Hence we hypothesize:

H8.a Organizations with defender or cost leader strategy will acquire information systems having high connectivity by making huge financial investments to fulfill their strategic requirements.

H8.b Organizations with differentiator or prospector strategy will acquire information systems having high connectivity by making huge financial investments to fulfill their strategic requirements.

3.9 Rapidity

It is defined as the degree to which hardware/software can deliver information whenever it is needed. Rapidity demands that IT/IS components/elements should be standardized throughout the organization. We refer rapidity as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. Rapidity as a distinct IS characteristic can be related with the business/market environmental conditions which can stable or dynamic. Hence, IS rapidity is low for defenders due to environmental stability but it should be high for prospector owing to unstable or dynamic environmental conditions.
Hence we hypothesize:

H9.a Organizations with defender or cost leadership strategy have information systems which are low in rapidity owing to the presence of stable environmental conditions.

H9.b Organizations with differentiator or prospector strategy have information systems which are high in rapidity owing to the presence of dynamic or competitive environmental conditions.

3.10 Facility

Facility can be defined as degree to which hardware/software can be used with ease and without any complications. Its implications may be building user-friendly applications i.e. web based or menu driven and creation of manuals/documentation for each hardware/software components. Additional features includes the use of single terminals to operate on different platforms/operating systems and ease of use of applications by non IT professional without intensive training. We refer facility as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. Organizations with a defender strategy have IS/IT systems of fixed or limited characteristics. On the other hand, prospectors IS/IT systems are more complex owing to multiple characteristics.
Hence we hypothesize:

H10.a Organizations with defender or cost leader strategy implement single process ERP software/information systems which are low in facility.

H10.b Organizations with differentiator or prospector strategy have information systems implement multi process ERP/information systems which are high in facility.

3.11 Modernity

Modernity is defined as the degree to which hardware/software is based on well-known products and technological trends. It refers to implementing hardware/software that are reputable or based on current technological trends. We refer modernity as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. Organizations with either a defender strategy will be characterized by IS/IT systems which are fixed or limited in technological capabilities suiting to the respective strategic requirements. While prospector type organization's IS/IT resources will be based on technological trends matching the respective strategic perspective.
Hence we hypothesize:

H11.a Organizations with defender or cost leader strategy have information systems which are low in modernity.

H11.b Organizations with differentiator or prospector strategy have information systems which are high in modernity.

3.12 IT Personnel Competency

The ability of IT personnel to possess relevant skills and experiences to effectively perform IT activities. Some of the major functions which define competency of IT personnel includes understanding policies and goals of the organization, planning for future technological challenges, able to lead IT/IS projects by quickly teaming up, learning and applying new technologies. We refer IT personnel competency as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. Organizations with a prospector strategy will acquire a highly motivated workforce characterized by high IT competency.
Hence we hypothesize:
H12.a Organizations with defender or cost leader strategy have low IT/IS personnel competency.
H12.b Organizations with differentiator or prospector strategy have high IT/IS personnel competency.

3.13 Reconfigurability

The ability to reconfigure computing capability of a system, so that its behavior can be changed to match the current business requirements. It denotes the reconfigurable computing capability of a system, such that its behaviour can be changed by reconfiguration. Reconfigurable systems can repeatedly achieve distinct configurations and achieve different functional capabilities. The configuration changes allow the system to carry out different roles, evolve in capability, and survive through environmental disturbances or internal failures. We refer Reconfigurability as a flexibility dimension of IS/IT systems and relate it to organization's operational and manufacturing strategy. Organizations with either a defender strategy will have information systems which have certain fixed or limited specifications matching the strategic orientation and requirements. On the other hand, prospector type organizations will have information systems which can be reconfigured according to the changing needs and strategic requirements.
Hence we hypothesize:
H13.a Organizations with defender or cost leader strategy have information systems which are low in Reconfigurability.
H13.b Organizations with differentiator or prospector strategy have information systems which are high in Reconfigurability.

4. Measurement of the Proposed Research Model (Constructs Operationalization)

Construct	Type	Relevant Literature	Measures
Organizational Strategy	Defenders/cost leaders Differentiators/prospectors Innovators	Miles and Snow (1978) Miller and Roth (1994)	• Compete on price, offer consistent quality, deliver high performance product • Manufacture different variants of product as per customer requirements • Aggressively innovate new products and introduce cutting edge technologies
Information systems flexibility	Modularity or distributed system	Section 2.1 Table 2.1	• well defined modules representing functional components • data is separated from applications reusable systems • data captured in one part of organization is immediately available to everyone

	IS Integration	Section 2.1 Table 2.1	• Seamless integration of processes across functional areas • Standardization of business practices • Access to real time data • Data flow is streamlined • functions of management are integrated within the information system
	IS Interoperability	Section 2.1 Table 2.1	• Exchange and use information internally between the different modules and legacy systems • can itself modify the code of the different functional modules
	Loose coupling	Section 2.1 Table 2.1	• Different functional modules within IS can be reconfigured and modified. • Modules can be combined or coupled together as per the requirements of the organization • IS modules are autonomous and self-content
	Scalability	Section 2.1 Table 2.1	• Hardware/software can be easily upgraded and scaled on existing IT infrastructure • easily and quickly adapted for changing needs and standards • support business growth in the future able to handle increasing volume of data traffic
	Continuity	Section 2.1 Table 2.1	• Disaster planning and recovery are ready to launch • Data backups are adequately kept • IT personnel in any positions can be easily replaced • Hardware/software can be concurrently used by a large number of users
	Compatibility	Section 2.1 Table 2.1	• Applications can be used across multiple operating systems • Data can be shared across applications and operating systems • Data can be shared across departments and organizational boundaries • Provides multiple interfaces for data sharing
	Connectivity	Section 2.1 Table 2.1	• Authorized data can be accessed by external as well as internal parties through IT networks, regardless of location • All external parties (i.e. customers, suppliers) are electronically linked with the organization through IT networks

	Rapidity	Section 2.1 Table 2.1	• IT components (i.e. hardware, software database) are standardized throughout the organization • Speed of communication through IT networks is satisfactory for internal users • IT infrastructure is quick enough to adapt to changing circumstances
	Facility	Section 2.1 Table 2.1	• Single terminal usage for different operating systems • User friendly applications suitable for non IT personnel
	Modernity	Section 2.1 Table 2.1	• Hardware/software are based on well-known products and current technological trends
	IT Personnel Competency	Section 2.1 Table 2.1	• Skilled in multiple tools and recent technological trends (e.g. programming languages, operating systems)
	Reconfigurability	Section 2.1 Table 2.1	• Ability to reconfigure the computing capability of information system to match business requirements without much efforts (finance).

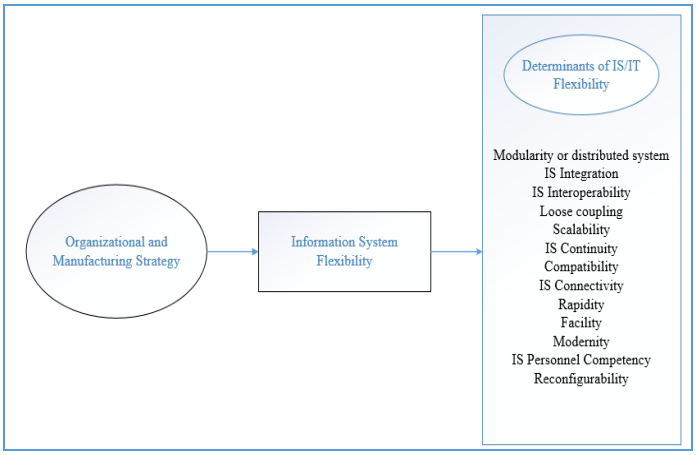

Figure 1: Proposed research model

5. Conclusions

Organizational information systems forms the backbone of organizations. In this paper, we particularly emphasize on manufacturing organizations. The operating and production strategy varies for different groups depending upon the market segment they target, prevailing environmental conditions and company's philosophy. The IS/IT system plays a significant role in supporting the organization's strategic decisions and implement related operations. This work tries to draw a relationship between organizational and manufacturing strategy and kind of IS flexibity required to sustain in the competitive environment. The developed theoretical framework can be further empirically investigated for insights.

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