ABSTRACT

Purpose The purpose of this manuscript is to develop a better understanding of how different degrees of vertical integration for the supply chain structure of a focal organisation shape the breadth of its technology portfolio.

Design/methodology/approach Three case studies were conducted with key players in the Australian retail sector with a distinct supply chain structure. A supply chain network perspective was taken which included manufacturers or suppliers, transport and logistics service providers as well as wholesalers/distributors of these retail organisations.

Findings We find several interesting aspects regarding the level, type, complexity and sophistication of information technologies employed by the three case organisations and their extended trading partners. We highlight how the choice of supply chain technologies is affected by their supply chain structure (level of vertical integration). We find that a disintegrated supply chain structures have broader arc of technological breadth whereas integrated supply chains have a narrow arc and is underlined with consistent standards.

Research limitations/implications (if applicable) This study is confined to three organisations in the Australian retail sector so any extensions should be conducted with caution.

Practical implications (if applicable) The framework developed by this study guides organisations in terms of assessing the appropriateness of their supply chain structure with the objectives of their supply chain systems. For standards setting bodies, the findings of this study suggests that technologies need to be tailored to the requirements of the supply chains (with the level of vertical integration being one easy way to segment the supply chain types).
Our study adapts and extends the ‘arcs of integration’ framework and propositions enhance our understanding of how the degree of vertical integration influence an organisation’s technology portfolio

Keywords: supply chain management, technology, arcs of integration, retail sector

1. INTRODUCTION

The supply chain literature has established that integration with customers and suppliers leads to improved performance (Frohlich & Westbrook, 2001). Therefore, organisations are seeking to ‘widen their arc’ of integration by collaborating closely with both upstream and downstream trading partners in the supply chain. The plethora of technological solutions available to organisations enhances the feasibility of integration. However, integration remains a distant reality for most organisations. This is essentially because an organisation’s technological portfolio is dominated by propriety stand-alone (legacy) systems or the result of acquisitions in an organisation’s growth trajectory or compliance to technology mandates by the dominant trading partners in the supply chain (Bhakoo & Choi, 2013).

The degree of vertical integration and the network structure that the organisation is embedded also shapes an organisation’s technological portfolio, which refers to the “portfolio for hardware, software applications, business processes, databases, and electronic networks” (Tiwana, 2008, p. 1242). The closer coupling with customers and/or suppliers that results from vertical integration has influential bearings on the characteristics of a firm’s technological portfolio (Teece, 1996). As such, these portfolios are commonly characterised as being either technologically diverse (i.e. vast array of technologies where knowledge is spread across many technology fields) or technologically coherent (i.e. narrow set of technologies that draw on a common underlying knowledge base) (Leten, Belderbos, & Van Looy, 2007). It is the latter issue of governance that interests and intrigues us as the supply chain management literature has examples of successful organisations with vertically integrated supply chains (e.g. Zara) to disintegrated structures (e.g. Apple). This implies that the resultant technological portfolios employed by these supply chains would also differ. The key research question we pose is: How does the degree of vertical integration shape an organisation’s technology portfolio?

In answering this research question we draw on the seminal work of Frohlich and Westbrook (2001) and employ concepts from the innovation management and information systems (IS) domains. Since the nature of our research question is exploratory, we adopt a theory elaboration approach and conduct case studies with three dominant players in the Australian retail industry and their extended supply networks.

Our study makes two distinct contributions to the supply chain and IS literature. First, we add supply chain structure as a critical construct that shapes an organisation’s technological portfolio. Our findings show that dominant players in the supply chain will customise their technological portfolio based on the degree of vertical integration. Thus vertically integrated supply chains will be more ‘technologically coherent’ drawing on a similar knowledge base for their technological solutions whereas vertically disintegrated supply chains will have technological portfolio that is diverse. Second, we propel the debate on external integration by developing a better understanding on how extended players in the supply chain may need to customise their technological portfolio depending on whether they are interacting with a vertically integrated or disintegrated supply chain.
The remainder of the paper is structured as follows – first we define and discuss Frohlich and Westbrook’s (2001) “arcs” framework and extensions to it and critique it – this is followed by a review of integrative technologies which culminates in a proposed ‘dual arcs’ framework with the dimensions of supply chain structure and technological breadth. This is followed by the research method adopted and we discuss the finding of the three supply networks in the retail industry in Australia. The discussion section highlights the contribution of the study to the extant supply chain literature and we offer specific recommendations to practitioners working within the area of setting technology standards.

2. LITERATURE REVIEW

2.1. Arcs of Integration and Vertical Integration

This study draws heavily on the “arc of integration” concept based on the seminal work of Frohlich and Westbrook (2001). The arcs framework advanced the understanding of integration by stratifying the degree and direction of supply chain integration into five distinct categories that ranged from extensive integration (i.e. “outward-facing”) to narrow integration (i.e. “inward-facing”). Based on an international sample of 322 manufacturers, Frohlich and Westbrook (2001) study indicated that companies with the widest “arc of integration” represented the greatest extent of integration that simultaneously encompassed both suppliers and customers and was argued to be superior to other integration strategies. Distinct from other frameworks, the “arcs of integration” provides a novel and visually distinct approach to the study and understanding of supply chain integration. Since it was first introduced over ten years ago, there has been mounting empirical evidence that verifies Frohlich and Westbrook’s (2001) original findings; that a firms’ integration strategy is related to their operational and financial performance (e.g. Bagchi, Ha, Skjoett-Larsen, & Soerensen, 2005; Schoenherr & Swink, 2012). However, findings from other studies have cast some doubt about the deterministic connections between supply chain integration and performance (Van der Vaart and Van Donk, 2008). For instance, a study by Pagell (2004) found that various other factors (e.g. organisation structure, culture, etc.) can act to either facilitate or impede integration. These studies highlight that while the “arcs” model has been widely cited in the extant literature, there are richer insights to be gained by empirically validating, refining, expanding and adapting the model across different contexts (Childerhouse & Towill, 2011).

A notable limitation of past studies that have applied the “arcs” framework is that integration is predominantly examined from the perspective of manufacturers rather than retailers and distributors. Given the distinct differences in their cost drivers, operational objectives and strategic imperatives, the generalisations of findings to the retail context are tenuous at best. Further, the integration scales used by Frohlich and Westbrook (2001) and other similar studies (e.g. Schoenherr & Swink, 2012) were exclusively focused on relationship strength (e.g. supply/customer relationships that go beyond sales transactions) and inter-entity interfaces (e.g. joint EDI access/networks). Those scales excluded measures of supply chain structures which is a critical oversight given that vertical integration may serve a role in the overall effectiveness of supply chain integration efforts.

The exclusion of vertical integration from the “arcs” framework is characteristic of the extant research on supply chain integration, which has been strongly biased towards collaborative approaches (e.g. strategic alliances, information sharing, etc.) to integration rather than through ownership structures. This is because extensive vertical integration is typically considered to be an inferior and extreme form of coordination (Guan & Rehme, 2012). These
views are premised on exhortations that vertical integration entails intense capital ties to assets that consequently compromise a firm’s ability to adapt and respond to environmental changes and volatilities (Teece, 1992). It seems that as partnership models and technologies become more sophisticated, supply chain management is becoming less about large investments in vertical integration but becoming more about temporal networks and robust interfaces (Van Hoek, 1998). This global trend of vertical disintegration (or fragmentation) has led to new governance and ownership structures resulting in a new and complex range of coordination and control issues in the management and study of supply networks.

A review of the literature reveals that the role of supply chain structure when examining supply chain integration remains largely uncharted. This paper doesn’t seek to advocate for or against vertical integration, but rather it seeks to acknowledge the legitimacy of vertical integration as a form of organizing. Accordingly, we adapt and reframe Frohlich and Westbrook’s (2001) original “arcs” framework and incorporate the dimension of vertical integration from a retailer’s perspective. As illustrated in figure 2.1, we assert that the pattern in the direction and degree of vertical integration falls within the same taxonomy of integration of the original framework which includes; inward-, periphery-, supplier-, customer- and outward-facing. The ‘arc of vertical integration’ corresponds to the extensiveness of vertical integration and the direction of the segment represents the orientation towards downstream or upstream entities.

![Figure 2.1 Arcs of Vertical Integration](image)

2.2. Role of Integrative Information Technologies in Supply Chain Integration

Modern integrative information technologies offer operational capabilities that are broader in reach and deeper in range than ever before which has been a disruptive force behind fundamental structural changes in supply networks (Bitran et al., 2007). The resource-based perspective proffers that a firms’ technology portfolio is a source of competitive advantage thus creating a strategic incentive for firms to develop, acquire and/or protect technological know-how resulting in portfolios that differ in terms of their composition of technologies. Technology diversity and technology coherence are often used to describe the array of firm technologies. According to Leten, Belderbos, and Van Looy (2007), a company that is technologically diverse has a portfolio that spans across many technological fields whereas technologically coherent describes a portfolio that shares a similar underlying knowledge
base. For example a technological diverse portfolio would have different technologies (EDI, phone/fax and legacy systems operating on different platforms with little connection amongst them).

Generally, technological diversity is associated with positive outcomes for firms as it enables the cross-fertilization of knowledge which fosters product and process innovations (Garcia-Vega, 2006). Further, firms’ utilising diverse technologies are better equipped to respond to and address market opportunities and threats (Autry, Grawe, Daugherty, & Richey, 2010). However, technological diversification is not without its challenges and drawbacks. Internally, organisations with highly diversified technology portfolios are more likely to encounter issues with the inter-operability of their information systems and technologies resulting in higher communication, integration and coordination costs (Granstrand, Patel, & Pavitt, 1997; Leten et al., 2007). The key challenges from a network perspective are the critical compatibility and assimilation barriers when interfacing with trading partners (Cohen & Levinthal, 1990).

The degree of coherence or diversity in a firm’s technology portfolio is situational and dependant on cost-benefit trade-offs. In subscribing to the same logic Frohlich and Westbrook’s (2001) “arcs” model, figure 2 provides as visual representation of an organisation’s technology portfolio that is interpretable via an ‘arc of technological breadth’. A narrow arc signifies ‘coherence’ whereby firm’s technology portfolio is highly focused and draws on a common underlying technological knowledge base of the company (e.g. proprietary technologies, ERP modules from the one vendor, etc.) which enables a higher level of internal integration. When an organisation subscribes to a common and consistent set of technology standards for bar coding and electronic messaging then it is considered technologically coherent. A wide arc signifies ‘diversity’ where the firm’s technology portfolio consists of a vast array of technologies that are spread across many technological fields and sources (i.e. not single sourced). The direction of the arc segment corresponds to whether a firms’ technological portfolio is customer or supplier oriented.

![Figure 2.2 Arcs of Technological Diversity](image)

**2.3. Adapted Model: The Dual ‘Arcs’ of Vertical Integration and Technology Diversity**

Various explanations have been advanced to elucidate the factors that influence firms’ technology portfolios such product complexity (Rycroft & Kash, 1999), organisational learning (Garud & Karnoe, 2002) and absorptive capacity (Granstrand et al., 1997). Some
scholars have asserted that the breadth and composition of a firm’s portfolio of supply chain technologies is, in part, a reflection of supplier-customer power relationships (Hingley, 2005) and the past problems, interests, and capabilities associated with those relationships (Granstrand et al., 1997). However, studies within the supply chain domain have tended to examine technology as having one-directional influences on supply chain (e.g. Dedrick, Xu, & Zhu, 2008). Further, based on findings from past studies on process reengineering it would seem that as vertical integration and technology increases the breadth of process alignment thus enhancing the financial performance of a firm (i.e. broad arc of vertical integration and technological breadth) (Hall & Rosenthal, 1993). There has been scant attention given to exploring the reciprocal influences of firms’ technology portfolio and their supply chain structures. Thus, drawing on our discussion thus far we arrive at the core focus of this study which is to understand the role of supply chain structure in shaping the arc of technological breadth. Figure 3 illustrates a variant ‘arcs’ model that superimposes the ‘arc of vertical integration’ with the ‘arc of technological breadth’ to visually convey the relational pattern between the breadth of a firm’s technology portfolio and their degree of vertical integration.

Figure 2.2 Dual Arcs of Vertical Integration and Technological Diversity

3. RESEARCH METHODOLOGY

The key research question posed in this study is: How does the degree of vertical integration shape the arc of technological breadth (coherence or diversity) of an organisation?

The nature of this research question is exploratory and seeks to develop a better understanding of an organisation’s technology portfolio. Therefore, we adopted an exploratory case study approach (Eisenhardt & Graebner, 2007; Meredith, 1998; Yin, 2003). Since we are drawing and seeking to adapt the ‘arcs of integration’ framework by Froehlich and Westbrook, we have adopted an inductive case study research method for theory elaboration (Lee, Mitchell, & Sablynski, 1999).

3.1. Sampling

In order to get a better understanding of the research question, we focused on the retail industry. We chose the retail industry as it is considered relatively mature in its adoption and
diffusion of technologies. In addition, the retail industry in Australia has supply chains with different governance mechanisms from vertically integrated to disintegrated supply chains that operate very successfully and it was essential to include each of these supply chain structures in our research design. Our focal unit of analysis was the retail organisation however we designed our research to take a supply chain network perspective to include organisations such as manufacturers/suppliers, third party logistics providers, grocery retailers and organisations setting technology standards in our research design. The suppliers were carefully selected to ensure that they were supplying to multiple players in the retail industry so that diverse opinions/perspectives could be captured. In terms of the technologies that were investigated we were interested in supply chain technologies that facilitated processes such as procurement and inventory management and therefore facilitated information exchange amongst trading partners in the supply chain. These included bar coding, data synchronisation tools, ERP systems and electronic messaging including EDI. Figure 3.1 below highlights the networks of the focal organisations (Org A, B and C) participating in our study.

![Supply Network of each retail organisation participating in the study](image)

**Figure 3.1 Supply Network of each retail organisation participating in the study**

### 3.2. Data Collection and Analysis

The data was collected from organisations in Australia during March 2012 and July 2013. Since the focal organisations in the supply chain were the dominant retail players in the industry, initial contact with these players was established through GS1 Australia since this organisation was funding this research project. GS1 is a globally recognized standards organisation that is responsible for the identification of all trade items, processes, services, shipments, assets, companies and locations to facilitate communication, data collection and exchange of information for all trading partners in the supply chain. This is done through allocation of unique identification through barcodes on products and electronic messages such as orders, invoices and dispatch advices (GS1, 2013).
Twenty interviews were conducted with senior supply chain managers, technology specialists and business solutions managers. These interviewees on average had over 10 years of experience of working in their respective industries. Each interview lasted 45 minutes to around one and a half hours. All the interviews were recorded and transcribed verbatim. The ethics clearance received stipulated that the names of the organisations and the interviewees should remain anonymous throughout the process. The interviews were supplemented with site visits and in some cases the informants were interviewed multiple times. The interview protocol was modified when interviewing personnel from different tiers in the supply chain. For example the questions were adapted when interviews were conducted with supply chain managers of the supplier organisations. These organisations were specifically asked how the supply chain structure of the retailer impacted their ability to exchange information through their inter-organisational systems. Interviews were conducted with personnel that held similar designations across the tiers. For example, we interviewed IT Managers, Chief Information Officers (CIOs), Customer Relationship Managers and Logistics or Supply Chain Managers who worked with distributors/suppliers and Supply Chain Managers, Operations Managers, IT Managers and Strategy Managers who worked with grocery retailers. This process enabled us to strengthen the external validity of our findings (Yin, 2003). We continued the interview process and added more interviews until no new themes were emerging (Eisenhardt, 1989; Glaser & Strauss, 1967).

In order to ensure reliability of our data the drafts of the case study reports were reviewed by the interviewees. In order to triangulate the findings, we also conducted interviews with six experts who had over 15 years of experience in the industry.

The unit of analysis is the focal retail organisation although we have included perspectives of the extended supply network. We analysed the data inductively and the key themes that emerged were type of technologies (coherent or diverse), motivations for using technologies, impact of technologies on integration activities, the distribution structure of the organisations and future use of supply chain technologies. We were guided by Miles and Huberman (1994) and OM scholars who have conducted a within and cross-case analysis for theory building inductive studies (Mahapatra, Narasimhan, & Barbieri, 2010; Wu & Choi, 2005).

4. FINDINGS

In our findings section, we first conduct a within case analysis for the three focal organisations. We also include perspectives of their extended trading partners. Thereafter, we conduct a cross case analysis.

4.1. Supply Chain 1 (SC1): Totally Vertically Disintegrated

Organisation A, as the focal organisation of SC1, is a leading marketing and distribution company within the grocery, liquor and hardware wholesale industries. Organisation A’s customers are independent retailers and the company’s objective is to champion and support them. It does so by providing the scale necessary to create competitive buying power together with marketing, distribution and financial expertise and support.

In terms of its supply chain structure, manufacturers and suppliers provide the merchandise to Organisation A, which then supplies to retailers who are predominantly independent operators. As this organisation does neither “own” the upstream suppliers or downstream retailers, the structure of this supply chain can be considered to be “ Totally Vertically Disintegrated”.

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Organisation A as the dominant player in the supply chain has a range of different technological solutions in place that range from dial up legacy systems to e-business solutions and portal technologies. One of the reasons why this organisation has a wide range of technologies, both from the customer and supplier perspectives, was because it has expanded through acquisitions. It has maintained a vast array of old technologies and has not attempted to implement a consistent bundle of technologies across the group. This issue was voiced in the discussions with the senior strategy manager in the following quote:

“when we acquired a company in WA, they had a plethora of customers, disparate customer groups who all submitted their orders and their interactions with Organisation A in their own proprietary formats, and so when we acquired that company, we couldn’t say use the our format, so we had to build all these new interfaces to cater with all these disparate customer requirements, and that’s a big challenge for us”

The other rationale for having different technological solutions is to build flexibility and robustness into the system. This implies that it has excess built-in redundancy and the ability to respond to customer needs.

On the customer side this organisation has portal technologies. For example they use portal technologies for the liquor arm of their business because it fits with how hotels and other outlets use their own technologies. They also use dial up technologies for some of their smaller retail outlets. There are a myriad of technology options on the supplier side which includes dealing with over 3000 vendors such as dial up technologies for incoming orders and outgoing electronic catalogues. They also have EDI with the top 100 suppliers who represent 58% of the purchase volume for purchase orders, purchase order acknowledgement and electronic invoices. In addition, they have a web portal that is used by 3000 suppliers who represent 50% of the purchase volume and do not have the expertise to implement EDI. Due to their control downstream in the supply chain, it was not well integrated. Their use of these diverse technologies indeed sought to widen the arc of technological breadth. Since it uses a myriad range of technologies including a number of legacy systems, its primary goal is to remove the ageing and non-supported technologies. The supply chain manager in this organisation quipped:

“we want removal of ageing and non-supportive technologies and want technologies that are reliable, supportive and effective. However, we also want to ensure that our technologies are flexible to deal with trading partners and it would be great if there is consistency”

This organisation made constant comparisons to the supply chain structures of Org B and Org C as they were the other major retailers dominating this space. Further, it is attempting to develop smoother relationships with trading partners with increased control, visibility, traceability and accountability with lower cost. Finally, to improve accuracy and efficiency in logistics, this organisation was also seeking at establishing greater standardization in its supply chain. This was explained in detail in the interview with the supply chain manager:

“...to have a common B to B infrastructure that’s reliable, supportable, effective. We want it to be standards based, supporting SLA, XML, Web Services and AS2, and we wanted also to provide a platform for the future, so that we could be business focused. However that’s a future directive, at the moment migrating everything off the old platforms onto the new platform is a significant motivation and challenge.”

In SC1, system integration is a significant challenge. This is essentially because a myriad set of technologies is employed both at supplier and retail ends, and a series of legacy systems
and dial up technologies is still being used. The following quote by the senior IT manager captures this sentiment:

"for the moment with all these disparate technologies and integration layers, it’s very very difficult to get things done, so we manage to get things done but that’s the challenge”

Therefore, buffer inventory must be maintained due to poor inventory visibility at the retail end. Also around 40% of the merchandise that these retailers sell are not supplied by them but other suppliers although it might be in their warehouse. Further, since a large number of its downstream retail outlets are independent retailers that have a number of proprietary systems, these invariably were inherited by SC1. Therefore, consolidation stands out as a major challenge. Adding to this complication is that retailers in different states have to respond to requirements of their disparate local customers who use their own proprietary formats for recording inventory and technologies for interactions and are unwilling to change to the ‘SC1 way’. Therefore, the focal organisation in SC1 has to build new interfaces to cater for disparate customer requirements.

As illustrated in Figure 4.1 below, Organisation A has a vertically disintegrated supply chain (i.e. narrow arc of vertical integration) which corresponds with a technology portfolio that is highly diverse (i.e. wide arc of technological breadth). The chief supply chain manager explained that they have suppliers running at ‘different speeds’ or different levels of technological maturity therefore it is imperative for Organisation A to have a wide arc of technological diversity.

Proposition 1: Focal organisations with vertically disintegrated supply chain structures have diverse technology portfolios.

![Figure 4.1 Dual Arches for Org A and its extended supply chain](image)

**Figure 4.1 Dual Arches for Org A and its extended supply chain**

### 4.2. Supply Chain 2 (SC2): Partially Vertically Integrated

Organisation B, as the focal of SC2, is a leading Australian food retailer, with more than 100,000 employees and over 11 million customer transactions a week. Dwelling into distribution channel for this organisation, it currently has four distinct distribution models. The first one is where the goods are supplied directly by the suppliers for products with a short shelf life. This organisation also runs its own distribution centres for some products.
However, the predominant model they use is an ‘open book’ third party logistics model. In this model Organisation B builds the warehouse and the systems but outsource the running of the system to a third party logistics provider. The cost structure for running the distribution centre is transparent and a specific profit sharing margin is agreed upon. Finally they have a ‘closed book system’ where the service is completely outsourced to a third party provider. The reason they have a mix of open and closed book so that they familiar with the business and have a fair understanding of how this business is run. In a closed system the IT used is completely at the discretion of the third party provider. As a consequence of the distribution model of Organization B and the level of control that it exerts on its upstream suppliers this organisation can be classified as “Partially Vertically Integrated”. Both under the closed and open model Organisation B relies significantly on this third party logistics provider to do both planning and execution.

On the supplier side it uses EDI integration with its top 100 suppliers. It also makes use of a supplier portal for procurement purposes, tracking past performance and making future forecasts and sharing information on upcoming promotions. Due to the 3PL activity that is outsourced it manages the relationship electronically. In terms of SC2, the focal organisation’s primary motivation is to increase productivity and reduce cost through the automation of business processes within the stores and across the supply chain (e.g. scanning barcodes, EFTPOS payment, warehouse management systems, and transportation management systems). Its reliance of the 3PL’s is to reduce the costs in the system. Further, their customer relationship management systems seek to collect more detailed personal information about customers and their purchase behaviors (e.g., using loyal systems, online commerce, mobile apps, website, etc.). Such information assists the organisation with market segmentations by differentiating its products in the marketplace and providing products and services that meet the requirements and expectations of each customer segment.

The planning and warehousing technology in this organisation is not state of the art which is essentially because it attempted to get sophisticated before improving its processes, which the quote below illustrates:

“Basically what happened is that they [Organisation B] tried to get sophisticated before they had control over the process and therefore there were a lot of exceptions, you know, there were a lot of problems of exceptions. Organisation C went the other way, they said let us get control of the process and make sure that all the components are correct and well understood and in good shape before we try to get too fancy.”

(e-supply chain consultant, Supplier N)

The issue of excess capacity is to ensure that the supply chain is robust and well integrated and with the other dual objectives of building a buffer capacity to deal with contingency planning, as the quote below by the Business Solutions Manager of the third party logistics provider highlights:

“The problem with Organisation B is because of that variability still within their supply chain, even though they know it’s all their own products, because that product master isn’t getting it right, and it’s not integrated into the WMS. So you’ve got to have extra safety capacity there just in case it blows out or you have to start moving the loads around between trucks, this might be two hours before it’s due to go out and that can take a lot of effort to move twenty pallets around between different trucks in the DC. Then you’ve got labour issues in the warehouse about whether there’s enough people on to actually do that work, so it’s all about, it is a supply chain issue because there’s
variability within our supply chain and cut that variability out, it cuts a lot of cost down. Otherwise you’re paying for it with safety capacity.”

(Business Solutions Manager, Third Party Logistics Provider)

For SC2, one of the major challenges is that there is a shortage of human resources, with major technology implementation projects being initiated by other industries around the same time (e.g., banks). This has put additional pressure on the ability to secure the required resources. This organisation also alluded to the fact that the time line for the implementation and roll out of a new technology was fairly long as the quote below highlights:

“Most big technology things take a long time to roll out. Retail has very short horizons in terms of expectations, so while the business at a high level has a five year plan, it tends to be, and has to be much more reactive to the market than many other industries. With supermarkets we can’t afford to fall behind even a little bit because we could lose customers very quickly, it’s much easier to lose customers than to gain customers in the supermarkets. People are creatures of habit, so once they’ve got the habit of shopping with our competitors it’s very hard for us to pull them out.”

The other challenges this focal organisation faces in its supply chain were in terms of evaluating and reviewing the performance and efficiency of new ways of doing things through a holistic approach (not just the technology aspect, but the whole process aspect). Second, bundling up several changes into one major change program to deliver the change more efficiently and embed the new technology in the way of working holistically.

Organisation B in SC2 is keen on moving away from complex application architecture to complex integration architecture, as the quote below from the head of strategy and architecture at Organisation B highlights:

“In terms of the amounts of different technology we have in terms of applications, in a sense we’re taking complexity out and putting it in at the same time in a strange sort of way. So as we get rid of legacy and the bespoke systems, which however complexity and replace them with packages of just simpler, that’s a good thing. However, we are having to integrate all our packages together, so we have a complex integration architecture, so again we moved away from a complex application architecture to a complex integration architecture over time. What that means is we are getting more and more dependence on smart ways of doing integration, so ESPs, ETL, EAI, these types of things are becoming increasingly more important to us as we are managing that complexity.”

Adding onto this the key philosophy in their IT strategy is to re-use, buy and then build. In selecting technology solutions their priority is ‘flexibility’ so that they are able to solve multiple problems.

Proposition 2: Focal organisations with partially vertically integrated supply chain structure have a relatively narrow arc of technological breadth
4.3. Supply Chain 3 (SC3): Totally Vertically Integrated

SC3 has Organisation C as its focal organisation and is one of the largest grocery chains in Australia. This organisation views its “backroom” operations as a source of sustained competitive advantage. As such, it has invested significant resources over a long period of time to develop in-house capabilities for the effective management of its warehousing, distribution and retail operations. While the suppliers engage with Organisation C in the traditional manner from the time goods are received in Organisation C warehouses, however thereafter these are fully managed by the organisation itself. As such, this focal organisation’s supply chain can be regarded as being a vertically integrated supply chain where the governance mechanism is tight control over the retail outlets and central planning is conducted for transportation and warehousing, although some of the execution is outsourced to a trucking services provider (see Figure 1 for details).

This organisation has implemented a variety of technological solutions ranging from e-business portals, EDI, RFID to phone/fax to transact with suppliers. Although there were different technologies being used in the organisation, the underlying theme that surfaced across all the interviewees within the organisation and its suppliers was a strong focus on standardising interfaces and integration amongst the systems. In fact, the issue of standardisation and data quality was at the forefront in the discussion with the interviewees. Since this organisation had a diverse supplier base of 4500, having a consistent technological interface although highly desirable would indeed be a complex undertaking and therefore they were customising the technological solutions accordingly. In fact, a new role had been created to connect the supplier community electronically and to consolidate data quality issues as categorically stated by the director of the e-business program “master data is becoming more critical in our organisation because of the fact that if it’s wrong it impacts everything downstream and that’s a significant challenge for us”

There was a strong element of technology coherence with the development of the supplier portal which was inspired by the fact that it acts a ‘one stop shop’ for the suppliers to get performance scorecard, and it also interfaces with other applications such as managing product recalls. The other interesting comment made by the service delivery manager was that in an attempt at standardising interfaces this organisation (literally) developed an in house warehouse management system which is based on an off the shelf product acquired from a vendor as the product was adapted to the organisation’s existing processes.
Their approach is about ensuring that the system matches their process requirements and customise the solution accordingly as the quote below illustrates:

our warehouse management system, we went in trying to use the off the shelf type system, the vendor could not keep up with us, developing it quick enough, so we ended up doing it all ourselves, and we’ve now got a system which is based on their off the shelf product but with about 1400 changes to it, so we now can’t go get the next version because we’ve made that our own,

SC3, the key challenge in the supply chain is developing an end to end integrated supply chain, even though it is acknowledged as the leader in the industry within this industry sector. This fact was recognised both by its competitors and its suppliers. Therefore, high on the agenda for this organisation is to encourage some of the suppliers (e.g., farmers) to purchase bar-coding systems and barcodes pallets that are sent to its warehouses. Their goal was also to manage product recalls effectively and have the ability to isolate batch numbers with products and this can be tracked in the warehouse. The reason this issue is gaining momentum is because of the trends across social media. It is important to stay abreast of trends surrounding social media applications such as customer expectations (e.g., having mobile applications for online shopping). Finally, even though this organisation is a leader within the industry, it is very keen to keep abreast of the changes taking place with the competitors in the local market as well as on the global platform.

![Dual Arcs for SC3](image)

Figure 4.3 Dual Arcs for SC3

Proposition 3: Focal organisations with vertically integrated supply chain structure have a coherent technology portfolio

5. DISCUSSION, IMPLICATIONS AND FUTURE RESEARCH

Our study has bought to the forefront the role of supply chain structure in influencing technological breadth of firms’ technology portfolio. In doing so, we have heeded the calls for future research that extend the application of Frohlich and Westbrook’s (2001) “arcs” model to other contexts and have added new dimensions to the framework. Whilst past studies have neglected vertical integration in their empirical investigations of supply chain integration, our findings have identified the legitimacy of vertical integration as a means of achieving an organisation’s integration goals. Even though organisations with different
supply chain structures had diverse technologies in their portfolio and the reason for the same was because they had small suppliers that they purchased a few lines and in that case flexibility was required from the major retailer in what kind of technologies they were using. The extant literature commonly cites that technology portfolios of large firms tend to be highly diversified (e.g. Patel and Pavitt, 1997). However, our study contests such generalisation whereby extensively vertically integrated supply chains appear to correspond with narrower and more coherent technology portfolios.

Although having a consistent set of standards is an underlying goal of a dominant trading partner in any supply chain; our dual arcs frameworks suggests that it becomes more difficult when supply chains are vertically disintegrated. As focal organisations embedded in such governance mechanisms move from vertically integrated to disintegrated supply chains their arc of technology breadth widens, and they employ a larger array of technologies (i.e. technologically diverse) and their coherence shrinks. This is evident with the typical supply chain technologies used within the four distinct supply chains, the range and variety is highest in SC1, followed by SC2, then SC3. The underlying reason for this technological portfolio in SC1 with Organisation A as the focal organisation was to ensure flexibility in dealing with trading partners upstream and downstream in the supply chain for SC1. SC2 that had a diverse technology portfolio was seeking to engage with customers downstream and develop strong integration amongst existing systems. The underlying rationale was to develop a more coherent set of technologies. Finally for SC3, the organisation was seeking improvement in cost and efficiency but the most important rationale was to ensure that their technological portfolio complimented their processes. With excellent standards and coherent set of technologies in place this organisation was seeking further upstream integration where their suppliers were able to monitor the performance of their suppliers (second tier) and share this information.

For standards setting bodies (such as GS1), the findings of this study suggests that technologies need to be tailored to the requirements of the supply chains (with the level of vertical integration being one easy way to segment the supply chain types). The findings also explain why supply chains continue to persist with large range of technologies, why some organisations choose not to implement the latest and best technologies, and why a “one-size-fits-all” model is unlikely to be applicable to all supply chains.

One limitation is that we have considered only three supply chains and confined our study to the retail sector. However, with our objective to understand how advanced supply chains with different supply chain structures configure their technology portfolio our sampling approach has brought some interesting insights into the literature. As with all qualitative studies that suffer from lack of generalisation and we are no exception and extensions of the study beyond the retail industry should be done with caution. One of the issues that surfaced in this study is that organisations were grappling with the perennial problem of too much or too little technology. We therefore suggest that it would be a very useful endeavor to conduct a large scale study on understanding the link between an organisation’s technology portfolio and performance. It would be interesting to know where the ‘tipping point’ lies as organisations seek to add technologies in their portfolio. A large scale empirical survey conducted with suppliers of large retail organisations would be an ideal sample for such as study. Constructs such as governance mechanisms would play the critical role of moderators in such a study.
6. CONCLUSION

This study conducted with three key players and their extended supply chains in the Australian retail industry has highlighted that the governance mechanism influences the character of the technology portfolio implemented in the supply network. We have found that focal organisations with a vertically integrated supply chain have a technological coherent portfolio whereas disintegrated supply chains are characterised by technology diversity. By employing the ‘arcs of integration’ framework and extending it along two dimensions: technology coherence/diversity and governance mechanism we have been able to contribute both to the information systems and supply chain literatures.

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