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Strategic Innovation Management in Global Industry Networks: The TFT LCD Industry

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Abstract: This study examines the strategic innovation management of the business creation process across the technology industry value chain in the global thin-film-transistor (TFT) liquid-crystal-display (LCD) industry based on an anonymous online survey of employees in the industry value chain and outside experts (universities, consultants, etc.). The study confirms that technology strategy formulation and a strategic center position are key industry concerns. It also affirms the utility of the industry value chain framework to manage technological innovations transcending that of a single company, and that strategic innovation management in global high technology industries incorporates a shared business creation process structure involving as many industry value chain partners as possible.

Key words: Global high technology industry networks, strategic innovation management, TFT LCD industry

INTRODUCTION

Globalization, de-regulation and innovative communication technologies have radically transformed the nature of opportunities and threats confronting corporations in such high technology sectors as the TFT (Thin Film Transistor) LCD (Liquid Crystal Display) industry. While long term market sustainability is ephemeral, new business creation (based on innovative product development) must be grounded on industry value chain integration, dynamically changing business boundaries and inter-firm relationships. In this paper, strategic innovation management of the business creation process across the industry technology value chain of the global TFT LCD industry is investigated.

TFT LCD industry network: The TFT LCD industry is part of the global Flat Panel Display (FPD) business involving diverse flat panel display technologies. Emerging in the 1980s, 2006 revenue was USD84.6 billion and USD100 billion in 2008. Major applications include desktop LCD monitors, mobile phones, notebook and netbook PCs and plasma TVs. LCD is a dominant industry technology with revenue share of 90% and a-SI (or TFT LCD) predominates. The main industry players are Samsung LCD, LG Display and AcerUnipac Optronics (AUO). The TFT LCD industry value chain incorporates the following elements:

- Suppliers of panel components [glass, color filter, electronics, chemicals, polarizer, backlit units (BLU)]
- TFT LCD manufacturers such as LG Display, Samsung Electronics, AUO
- OEM and ODM such as Quanta, Flextronic, TPV, BenQ
- Brand companies like Dell, Sony, Nokia, BenQ
- Channel companies like Circuit City, Best Buy

TFT LCD market dynamics are largely driven by cost and, hence, scale of shipments. Cost is driven by technology innovations in new materials, processes and products, plus manufacturing technology advances and hardware demanding huge investments; a Gen 7 manufacturing line exceeds USD 2 billion. Industry dynamics shifts reveal Japanese investments mainly in Gen 1-4 technologies (and partly in Gen 6-10), Taiwanese in Gen 4-8 and Koreans in Gen 3-10; volume shipments have moved from Japan, Korea and Taiwan and now to China.

Capacity expansion requires large, non-discrete investments but not precluding cyclical swings characterized by Mathews (2005) as follows:

- Firm rivalry: strategizing around cyclical turnaround points
- Demand side: new applications expand the market
- Supply side: newer fabrication technologies for cheaper products under uncertain investment returns in new and emergent markets

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- New entrants with existing technology: time-based market entry strategy during downturns
- Substitutes and alternatives: strategizing around new or alternative display technologies

Knowledge is the key element in high technology and fast-moving, emerging markets. In Murtha *et al.* (2001) framework, FPD industry competition is predicated on speed or timeliness while competitive advantage exploits competencies and functionalities. Sustainable competitive advantage must replace traditional protect-exploit-extend or adapt strategies with create-share-transcend and drive-for–the-next-generation dimensions. Firm efficiency and market focus must shift to knowledge-seeking behavior in internationalized R&D processes. Intra-firm networks with a multiplex structure replace the centre-outward or centre-inward focus. The global business trajectory builds upon a collaborative rather than a dominating paradigm, leveraging national strengths and overcoming protectionist tendencies.

The FPD industry encompassing the a-Si TFT LCD sector is pertinent to this paper as it:

- Is dynamic, fast growing and aggressively cost-cutting
- Has experienced innovative, large area display market creation
- Operates in a limited applications range in multi-billion dollar markets
- Dominates the FPD industry in sales revenue and future investment
- Encompasses a distinct value chain dominated by a few major players
- Recognizes that time is central to TFT LCD strategies
- Is knowledge driven, relies on speed, collaboration and competitive sustainability

MATERIALS AND METHODS

Product and process technology management requires a multi-disciplinary review of such substantive areas as technology management, innovation management, strategic management of technological industries, economic theory of networked organizations and business process management.

Management of technology: From the 1950s, management of technology has tracked the convergence of "engineering, science and management disciplines to address the planning, development and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization" (National Research Council, cited in Beard, 2002). It pre-supposes investments in tangible and intangible assets to minimize future cash flow uncertainties, enhance mid- to long-term value and organizational survival (Maritan, 2001; Srivasta *et al.*, 1999). Furthermore, it determines time-to-market, market share, product quality and innovativeness (Dutta *et al.*, 1999; Montoya-Weiss and Calatone, 1994; Moorman and Slotegraaf, 1999; Song and Parry, 1997).

Six phases define technology management (Fig. 1). The technology-push phase (1950 to mid-1960s) evolved from the World War II and Cold War demand for technology-intensive products but largely lacked explicit technology, innovation and corporate strategy linkages (Nobelius, 2004; Reisman, 1994). Market-pull technology management marked the second phase (mid-1960s-early1970s) where short-term market demand intensified market share competition while R&D was driven by project management and the internal customer perspective (Rothwell, 1994). The third phase (mid-1970s-mid-1980s) was rationalization-driven because of market saturation and technology portfolio management linking R&D to market demand (Edler *et al.*, 2002). In the fourth phase (early 1980s - mid-1990s), integration management forced a holistic business perspective integrating services, distribution and multi-product portfolios (Mikkola, 2001). R&D management embraced the new product development process (NPD) with the parallelization of steps (McDermott and Handfield, 2000) and cross-functional team integration (Holland *et al.*, 2000). The fifth phase (mid-1990s-early 2000s) of system integration reflected global de-regulation and intensifying competition involving: R&D efforts managed through centralized and de-centralized R&D matrix organizations (Edler *et al.*, 2002); strategic and operational partnerships among R&D, functional departments and external suppliers, customers or competitors (Duysters *et al.*, 1999); and fast development process management (Nobelius, 2004). The global shift to an information society in the 1990s catapulted Western corporations ahead of the Japanese who focused on R&D intensity (Yoshikawa and Watanabe, 2006). Beyond 2000 is the network integration phase in which business globalization and internationalization (Archibugi *et al.*, 1999) exacerbate technology management complexity (Hagedoorn, 2002). Interactive business and technology network strategies are more pronounced embracing multi-technology bases for high technology markets, integrated and distributed sourcing strategy and networked eco-systems sharing intellectual property to facilitate innovative insight and break-through (Nobelius, 2004).

Management of innovation: Innovation management, central to technology firms' long-term viability (Kfir, 2000) has been examined from diverse academic perspectives, methodologies and analytical units. This paper studies innovation management within the six technology management phases. In the technology-push, 1950s period, industrial innovation was the panacea to society's problems with more science creating more innovative products. Market pull demand shaped innovation output in the second generation while systematic learning transpired from the successful

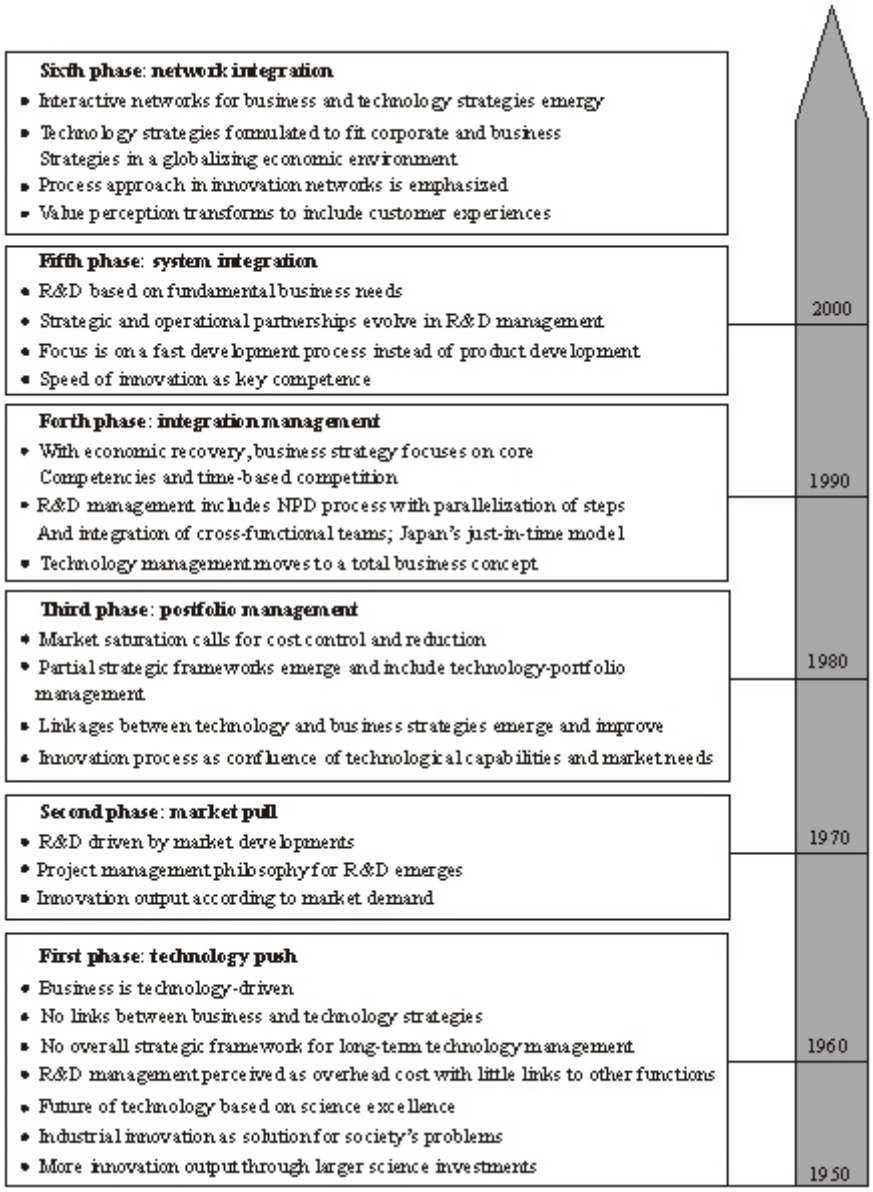

Fig. 1: Technology management timeline

innovations in the third generation. Fourth generation innovation was driven by Concurrent Engineering (CE) or Concurrent New Product Development (CNPD) and Japanese mastery of this process led to innovative breakthroughs: Japanese automakers, thus, introduced new cars within 30 months compared to their rivals' 48-60 months (McDermott and Handfield, 2000).

Sixth generation model of innovation management: This model, cogent to our paper, encompasses (1) business and technology strategizing in innovation networks, (2) migration in the market value proposition, (3) business process approach, and (4) the changing economic rationale for interactive networks.

- Business and technology synergized into interactive networks in which Lorenzoni and Baden-Fuller (1995) position the strategic center firm managing a network of partners driving value creation, leader and capability creation, and structure and strategy, while critically aligning network relationship degree, flexibility and freedom. Central to this is the innovative exploration and exploitation of network competencies differentiated by being first

or second-order (Danneels, 2002); type [financial, structural, intellectual, imagination, entrepreneurial and relationship (Hamel, 2001)]; stage-dominant, process-dominant or task-dominant transfer models (Shrivastava and Souder, 1987), and R&D internationalization and decentralization strategies (Andersson, 1998; Archibugi *et al*., 1999; Cantwell and Iammarino, 2000; Chiesa, 1996; Diaz-Balart and Rojas, 2002, Kuemmerle, 1997; Westphal, 2002) and the concept of a global innovation exchange (Moitra and Krishnamoorthy, 2004).

- Changing market value propositions influence market models, managerial viewpoints, perceptions, assumptions, interpretations, cognitions, and market value creation activities. The market-as-network approach recognizes that market equilibria represent the behavior seeking the best possible choice among various players while its innovation-averse tendency reflects market relationship strengths. Three network features push innovations: network externality effects, network equilibrium and network hubs (Chakravorti, 2004). Market-as-network is an innovation ecosystem in which "successful innovation requires tracking your potential adopters as you track your own development process" (Adner, 2006). It requires comprehending them as decision makers and resources allocaters (Bessant, 1998; Lefebvre, 1998; McCosh *et al*., 1998; Nystroem, 1998). In this paper, Storey's (2000) four dimensional framework incorporating the individual-social and internal-external axes is applied: individual-external dimensions reflect individual networking theory while the external-social dimensions explain managerial perceptions of inter-firm collaboration. Innovation management, transcending orthodox industry economics, includes resource utilization, knowledge sourcing, technological complexity and relationship management in dynamic network structures. Also, it recognizes the new innovation frontier in the co-creation of the consumer experience making it more "the experience of a specific consumer at a specific point in time and location in the context of a specific event" (Prahalad and Ramaswamy, 2003).
- This paper's central postulate perceives innovation management as a business process integrating technology industry participants in value creation. Business process has been diversely analyzed (Davenport, 1993; Gorbach, 2002; Hammer and Champy, 1994; Lindsay *et al*., 2003; Melao and Pidds, 2000; Van Rensburg, 1998; Wang and Wang, 2005). Two of the seven strategic themes in Business Process Management (BPM) are cogent: organizational coordination as the key to manage internal and external processes, and market value chain processes, appropriately linked, to generate innovations. Additionally, value chain explains all the business processes within a firm or network of firms including business fulfillment and creation activities. BPM recognizes that businesses migrate from a functional to a process-based approach. The key findings relevant to this research are: the conventional input-transaction-output model must be replaced by a flexible business process system incorporating interactions, relationships, human participation and environmental dynamics; a holistic approach is essential as espoused by Armistead *et al*. (1999), Cooper *et al*. (1997), Melao and Pidd (2000) and Wang and Wang (2005); clear definitions must guide innovation research as BPM; relative player contributions creating customer value require appraisal and BPM must investigate business processes dynamics in a networked space.
- Technology-oriented network evolution tracks intra-firm relationships to dyadic, inter-firm to web-based associations. The competitive metaphor driving business efficiency and performance becomes less restrictive and more inclusive of network business relationships and strategic alliances (Astley, 1984; Belussi and Arcangeli, 1998; Chiesa, 1996; Hamel *et al*., Gulati, 1995, 1998; Gulati and Singh, 1998; Kanter, 1994; Nielsen, 1998; Ohmae, 1989). The concept of co-opetition (Quintana-Garcia and Benavides-Velasco, 2004) and co-evolution (Watanabe *et al*., 2004) have surfaced synergizing the paradoxical forces of trust and commitment (to access external resources and capabilities) and opposition (to minimize core competencies leakage to collaborating firms). The social dynamics of building networks deepen and clarify network relationships (Koch, 2004) as networks of learning (Powell *et al*., 1996) leveraging on ICT to exploit global resources and capabilities in virtual networks as in a global R&D networked structure (Chiesa, 1996)
- This empirical work, thus, provides an innovation management direction to integrate the business creation processes in the global TFT LCD industry value chain.

Research propositions: The TFT LCD industry value chain reflects a network or ecosystem perspective with a large number of global players. An initial proposition, then, is that a hub position within the industry value chain is critical to innovation management:

P1: A dominant position in the TFT LCD industry value chain enables successful innovation management through a value chain-based business process.

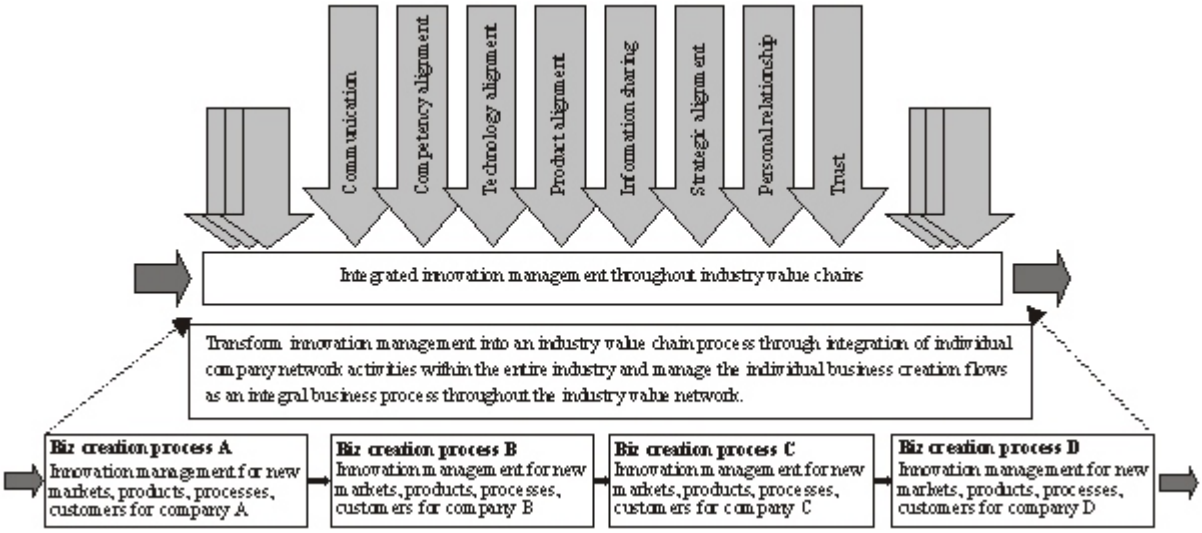

Fig. 2: Integrated value chain innovation management model

Dominant, strategic hub or centre positions describe a powerful and strategic location in an industry value chain network controlling the flow of information, goods and capital. Furthermore, given a dominant position in the TFT LCD industry, its location must be examined:

- Exploratory Question 1: If a dominant position exists in the TFT LCD industry value chain, at which element will it be located?

The TFT LCD value chain is the basic analytical unit in this exercise requiring precise definitions and unambiguous questions. Also, the manager, pivotal to innovation management, must be surveyed for perspectives on this process involving determinants given in Fig. 2.

This generates the second proposition:

- P2: Launching technical innovations successfully into a market depends on the approach to manage innovations in an industry value chain process.
  Where the locus of innovations has migrated from an individual company to a network of businesses, innovation management must embrace strategic, systemic and process-oriented dimensions:
- P3: The management of innovations must be based on a shared business process among value chain companies to successfully launch technological innovations into the market.
- Exploratory Question 2: Do companies in the TFT LCD industry value chain have an explicit technology strategy formulated? If so, how important is it?
- Exploratory Question 3: If an explicit technology strategy exists, does it follow a systematic process to launch technological innovations into the industry value chain? If so, how important is this technology strategy?
- Exploratory Question 4: If a systematic process exists to launch technological innovations into the industry value chain, does the technology strategy include explicitly dyadic (inter-company cooperation) or network (inter-company network) elements to create technological innovations?
- Exploratory Question 5: Does the shared business process in the industry value chain rely on collaborative more than competitive relationships among participants?
- Exploratory Question 5a: How important is the collaborative relationships between an individual company and the TFT LCD individual value chain participants in the creation of technological innovations?
- Exploratory Question 5b: In which of the value chain elements are the most important collaborative relationships necessary to support successful technological innovations?

Research limitations: Being exploratory research, the social aspects of networks, sociology of network organizations, organizational research or the conceptualization of a value chain creation cannot, realistically, be undertaken.

Secondly, it does not model innovation flows, process activities or actions in a network structure given resource limitations and recognizing the inappropriateness of linear models.

Finally, such terms as innovation, technological innovation, innovativeness and innovation performance are ambiguous and could be future research topics.

Research design: The unit of analysis is the large area TFT LCD industry value chain comprising component suppliers, panel companies, OEM and ODM companies, brand companies, and the channel companies selling to consumers.

The research population includes the individuals responsible for technical innovation management in the TFT LCD industry value chain sampled on a judgmental basis.

Research data was collected using a questionnaire in an anonymous online survey grouping. 62 questions under demographics, technology strategy, industry value chain and business process. To address the response rate issues in web-based surveys, various solutions were applied: monetary incentives, repeated contacts, issue salience, selectivity statements and participation deadline, university sponsorship and questionnaire length.

RESULTS

The survey, sent to 3482 people, yielded 64 responses or a 2% response rate. Based on Wimmer and Dominick's (2006) 20 year research experience, acceptable hyperlink-based web survey response rates are 1~30%. This study's response rate is related to the non-homogenous population, complex business process approach, length of the questionnaire, confidentiality of the innovation theme, Internet security and email-overload themes.

Exploratory Question 2: The respondents (84%) confirmed that TFT LCD industry players largely depend on either an explicit or incorporated technology strategy for successful innovation management. It was assigned a 4.18 mean value (on a 5 point Likert scale from 1 to 5 = very important). Its significance corresponded with the availability of an explicit (4.38) or an embedded (4.3) technology strategy.

Exploratory Question 3: Explicit technology launching strategy procedures into the industry were confirmed by 68% of respondents.

Exploratory Question 4: Inter-company technology cooperation strategy was affirmed by 69% of the respondents with 42% reporting inter-company networking. However, inter-company networking was reported by 52% of the respondents (explicit strategy) and 30% (embedded strategy). No inter-company networking was reported by 40% of the sample with an explicit strategy, 70% with an embedded strategy and 60% with no strategy. Such a pattern suggests predominantly traditional dyadic company interactions in the industry value chain with most companies at least at the fifth generation system integration level.

Inter-company network relationships exist mainly in companies emphasizing a technology strategy. However, the network structure can possibly replace the dyadic structure in future.

Value chain players (about 8%) with no technology strategy and rating it unimportant (mean value = 2.6) could be at the second generation stage underpinned by market-pull dynamics for innovation and technology management. Companies at the fifth stage value such procedures embedded in the (mean value = 4.43) technological innovation strategy.

Companies valuing technology strategy tend to advocate inter-company co-operation, a fifth generation model feature with strategic and operational partnerships with suppliers, customers and competitors (Edler *et al.,* 2002; Nobelius, 2004). 42% of the respondents recognize the importance of network integration within the sixth generation model: these are located mid-value chain at the 'panel' and 'integrator' elements.

Proposition 1 and exploratory Question 1: The Proposition 1 response confirms Hypothesis H1 of a dominant value chain position managing shared business processes for successful industry innovations. Also, Exploratory Question 1 demonstrates this dominant industry value chain position with an overall mean value for all industry players of mall = 8.71. The lowest ranking value, and, hence, most dominant position, was the 'panel' segment followed by the 'backlight unit component,' and 'LCD TV brand' segment. The dominant position of the 'panel' segment reflects reality in the more than US$ 2 billion investment in one 7th generation state-of-the-art factory.

Exploratory Question 5: The collaborative value chain segment relationships are relative to the dominant 'panel' segment in the industry value chain. Mean collaborative relationship (CR) values range from 1.81-3.22 with an average CR value for all elements of 2.66. In the respondent's own company segment (the 'n' relationship), CR is 2.67 ranging from 1.975 (the lowest CR value among branded companies) to 3.33 for the 'panel' segment companies.

The average CR value for the immediate supplier is 3.22 and for the immediate customer 3.19. Other average CR values include the supplier's supplier (n-2) of 3.21, and the supplier's supplier supplier (n-3) of 2.72. This compares with the CR value of 2.9 for the customer's customer, the n+3 relationship of 2.35 and the n+4 relationship of 1.81.

Several implications arise from these collaborative relationship values. First, 'panel' and 'integrator' elements value co-opetition among their 'n'-relationships. Both elements show the highest CR values in the 'panel'

segment of CR = 3.33, and the 'integrator' element of CR = 3. Both values are above the average 'n'-relationship CR value of 2.67. Other segment 'n'-relationship values are both below the average for the 'brand' element of CR = 1.975 and the 'component' element of CR = 2.37.

Second, CR values tend to decrease the higher and further the distance away from the 'n' company gets (n-2 or n+2 values are lower than n-1 or n+1).

Third, a stronger CR value on the supplier relationship relative to the customer side exists. For example, the n-2 average CR value is 3.21 while the n+2 value is 2.9. This is true for all supplier levels versus customer relationships: level one (n-1 versus n+1) comparisons are 3.22 versus 3.19; level 3 are 2.72 versus 2.35.

Fourth, it is confirmed that the 'panel' segment has the strongest collaborative relationships in the industry with an average CR = 3.38. Others follow with CR = 2.76 (for the 'brand' and 'integrator' elements) and 2.26 for the 'component' element.

Fifth, it is the 'panel' element which other value chain segments maintain the strongest collaborative links with. The 'brand' element has the strongest CR (3.73) with n-2 (the 'panel' element); the 'integrator' segment has the strongest CR (3.5) with n-1 (the 'panel' element), and the 'components' segment shows the strongest value of 3.67 with the n+1 relationship (the 'panel' element). The 'panel' element has an equally strong CR (3.67) with its customer (the 'integrator' element) and its customer's customer (CR = 3.67 with the 'brand' element).

Proposition 1: Exploratory Questions 1 and 5 align closely with the concepts surveyed in the literature review. The most powerful and relation-intensive firms occupy hubs (Chakravorti, 2004) or, similarly, when strategic center firms manage a network of partners (Lorenzoni and Baden-Fuller, 1995). A dominant position to manage innovations in the industry is crucial and this is located at the 'panel' segment.

The Exploratory Question 5 finding is that the 'panel' segment companies dominate the industry value chain exhibiting the most intensive collaborative relationships relative to their peers at the 'n'-relationship (within the same segment), dyadic (n±1 relationships) and value chain (n±2) relationships. The 'n'-relationships strength at the 'panel' and 'integrator' elements exhibits horizontal networking and co-opetition interaction (Bengtsson and Kock, 1999; Quintana-Garcia and Benavides-Velasco, 2004) or competitive-collaborative linkages (Hamel *et al*., 1989). Such horizontal network structures, underpinning technological product innovations, are, to Hakansson (1990), key for new market development and creation of new vertical customer-supplier structures. Panel companies have, indeed, driven new markets since the 1990s in three waves - from notebook TFT LCD to TFT LCD monitor to TFT LCD TV displays attained through technological product innovation and fab investment management creating the first global manufacturing industry sharing knowledge in horizontal networks (Murtha *et al*., 2001).

Proposition 2: Proposition 2 relates to innovation management within an industry value chain rather than as individual company processes. The Pearson correlation coefficients for the success factors between the n+1 and n+2 relationships are given in Table 1 with all variable combinations showing positive coefficients. This confirms H1 in Proposition 2 that success factors in a company's dyadic (n+1) and the industry value chain relationships (n+2) are correlated. All, except the three combinations (13-14, 44-45, and 49-50), show a correlation coefficient over 0.5 and a Cronbach's alpha over 0.7 (apart from the combination 17-18 with a Cronbach's alpha of 0.68 rounded to 0.7). With these exceptions, dyadic and value chain relationships show strongly positive correlations. The relevance of the success factors is, in all cases, supported, and, relate to the success factors identified in prior research.

The migration from technology management generations one to six is caused by rapidly changing environmental parameters. With globalization and global consumers, product- and service-centric innovation management has dynamically shifted to interactive, network-based innovation management (Nobelius, 2004).

Proposition 2 confirmed that, for innovation success, dyadic and customer's customer (and supplier's supplier) relationships (illustrative of a network structure) must be positively correlated. These success factors, identified in prior research in the dyadic environment (n+1, n-1 level), can be extrapolated to the n+2 (n-2) and, potentially, the n+3 (n-3), n+x (n-x) value chain relationship levels. This finding signals the migration of dyadic vale chain relationships to a networked industry structure to manage technological innovations.

Proposition 3: The capability to manage shared business processes in the industry value chain supporting the H1 hypothesis was confirmed. Aligning cross-company processes, for logistics and marketing in a networked business creation process, is linked to the super- efficient company. Such a firm integrates individual company activities into the industry value chain process where they fit best (Hammer, 2001). Innovation capabilities transcend internal company structures to where most economical, based on flexible and dynamic innovation networks (Sawhney and Parikh, 2001).

Study limitations: The literature on innovation/ technology and BPM is intellectually challenging due to the various definitions, fragmentation of methodologies,

Table 1: Summary: Pearson correlation coefficients

	Cronbach Alpha	N valid cases	12ComTechnolnnoWDlrSup	14ComTechnolnnoWDlrCust	18MgtKeyCompAcsWDlrSup	20MgtKeyCompAcsWDlrCust	23AlignTechnoRmpWDlrSup	25AlignTechnoRmpWDlrCust	28AlignProdRmpWDlrSup	30AlignProdRmpWDlrCust	33AlignGeninfoWDlrSup	35AlignGeninfoWDlrCust	38AlignConfStratinfoWDlrSup	40AlignConfStratinfoWDlrCust	43PerRelSkipWDlrSup	45PerRelSkipWDlrCust	48BldTrustWDlrSup	50BldTrustWDlrCust
11ComTechnolnnoWDlrSup	0.72	62	0.568															
13ComTechnolnnoWDlrCust	0.60	63		0.432														
17MgtKeyCompAcsWDlrSup	0.68	62			0.571													
19MgtKeyCompAcsWDlrCust	0.75	62				0.588												
22AlignTechnoRmpWDlrSup	0.89	63					0.811											
24AlignTechnoRmpWDlrCust	0.83	63						0.709										
27AlignProdRmpWDlrSup	0.81	62							0.679									
29AlignProdRmpWDlrCust	0.76	60								0.618								
32AlignGeninfoWDlrSup	0.83	62									0.694							
34AlignGeninfoWDlrCust	0.74	63										0.588						
37AlignConfStratinfoWDlrSup	0.80	61											0.663					
39AlignConfStratinfoWDlrCust	0.70	61												0.539				
42PerRelSkipWDlrSup	0.77	62													0.614			
44PerRelSkipWDlrCust	0.57	61														0.411		
47BldTrustWDlrSup	0.77	58															0.589	
49BldTrustWDlrCust	0.52	62																0.359

constraints in applicability and non-generalizability of research findings. However, there is broad appreciation that successful business performance requires a paradigm change from being competitive to being co-operative and working within an integrated network structure (Gulati *et al*., 2000).

No empirical research exists analyzing the business creation process within industry value chain parameters This study has attempted a descriptive analysis of the TFT LCD industry environment examining innovation management as a shared business process. Selecting the industry value chain as the analytical unit is a major research challenge due to the complex organizational relationships and business practices; number of global companies with their divergent political, social and cultural backgrounds; diverse economic perspectives of the industry value chain depending on the value chain element; and, the dynamics of technology-driven industries.

The 2% response rate limits the generalizability of the research findings and should be understood against research on web-based survey performance (Wimmer and Dominick, 2006).

The authors are confident of the study's findings and predict similar patterns in the TFT LCD industry in future research; this is based on the first author's active participation in it.

CONCLUSION

The evolution of the global economy has changed and will continue to radically transform competition in technology industries. As product life cycles decrease, with consumers demanding value co-creation and the power of financial flows, corporate survival hinges on a complexity of factors. Effective innovation management is one key to firm survival and growth (McKie, 2004). Despite extensive technology management research, no clear or simple technological or innovation management solutions are evident and, ironically, innovation failure rates are as high as research findings are fragmented. As business environments transform relentlessly, uncertainly and unpredictably, radical intellectual and managerial re-thinking of innovation and technology management is crucial. In this study, one such direction is proposed integrating the business creation process across the global TFT LCD industry value chain. This study confirms that technology strategy formulation, whether explicit or embedded, is a key concern of industry value chain players and requires managing innovation creation incorporating their dyadic relationships.

The significance of a strategic center position (or network hub) in the value chain 'panel' element to coordinate innovation management through shared business processes in industry value chains is confirmed by H_1 in Proposition 1.

The industry value chain framework to manage technological innovations is supported by the positive correlations between dyadic and network relationships implying that some theoretically grounded success factors relevant to a company's dyadic and network environments, confirming H1 in Proposition 2.

With the industry value chain framework to manage innovations as a shared business process, H1 in Proposition 3 is affirmed.

Thus, this study makes two contributions: one, an

industry value chain rather than an individual company perspective in technology management is paramount: two, managing innovations as a shared business creation process must involve a large number of industry value chain partners.

This study integrates the four key themes of the sixth generation model and adds exploratory empirical evidence based on a unique analytical unit. Thus, it extends this model by applying an industry value chain focus and BPM in innovation co-management by value chain players.

Resource constraints limited consideration of the social aspects of networks, modeling of the innovation flows through the value chain, and the formulation of performance metrics to manage innovations in industry networks.

The 2% response rate is on the lower side of the expected range for Internet-based surveys (Wimmer and Dominick, 2006) but should be weighed against web-based survey performance research.

Technology and innovation management, particularly in high technology industries, confronts major challenges and opportunities for which significant research investments are prerequisite. Specific applied studies on the transition from the fifth to sixth generations of technology management and technology strategy incorporating inter-company network links can deepen the understanding of the forces driving innovation management in the TFT LCD industry. The current findings cannot be adapted as such to other high-technology industries. Therefore, it would be a useful research exercise to analyze whether phenomena associated with the dynamic, high technology industry represented by the TFT LCD industry has generic commonalities with other industries.

This research study underscores the need to transform traditional and orthodox managerial mindsets to identify and incorporate emerging phenomena.

The key to the sustainability and survival of corporations in a dynamic and globally connected economy is not whether or not to undertake innovation. The dilemma is the methodology of attaining this fast-moving and elusive target; a business process approach for innovation management and the environmental setting of a networked industry value chain is a rich area for academics and practitioners to zoom into.

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