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**FIRM STRATEGY INSIGHTS FROM BUSINESS ECOSYSTEM  
FORMATION DYNAMICS**

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Doctor of Philosophy

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## ABSTRACT

This thesis provides a strategy framework as guidance for ecosystem linked firms to efficiently identify relevant ecosystems to engage with and influencing entities within them, access cross-knowledge and evaluate merits of specific positioning within the ecosystems.

Three ecosystem types are isolated from ecosystem related jargons in academic literature. Business Ecosystem (BE), Innovation Ecosystem (IE) and Digital Ecosystem (DE) were found to be the largely exclusive umbrella terms used. Using keywords analysis, topics that are exclusive or overlapping for these three ecosystem types are characterized into themes. Keyword network analysis revealed certain distinct larger or central domains which co-occur with others across the three ecosystems, as evidence of knowledge sharing across the ecosystem types. As firm strategy is found to be semantically represented as a BE topic with knowledge sharing from IE and DE, the next steps explore strategy insights from the lens of a firm as a BE actor.

The merits of a firm's engagement in specific positions of selected ecosystems is assessed through insights from dynamics of ecosystems formation. For a breadth coverage, the contrasting case studies of the more centrally themed global electric vehicles (EV) and the distributed ecosystems emerging from the Internet of Things (IOT) paradigm are selected. Global deals network analysis is applied to both cases to reveal clusters of heightened activity and their respective hub firms. The EV hub firms leading competing ecosystems mostly in different geographies are found to be evolving from diverse businesses of the EV value chain such as manufacturers of batteries, vehicles, cables, motors, electromechanical braking, assembly production systems, power distribution systems and charging stations. In contrast, the IOT linked hub firms are found to be non-competing incumbents that include online retail, semiconductor manufacture, exclusive smart device manufacture, telecommunication services and satellite based monitoring services. Subsequently, the hub firms are profiled based on the rationale of their deals to derive deal intentions and strategies employed by them.

The combined insights are collated and structured in a unified ecosystem firm strategy framework. In addition to guiding diverse product and services firms, the findings in this study offer directional basis to researchers, industrial associations, policy makers and other influencers.

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# CONTENTS

1. INTRODUCTION .....	8
1.1 OBJECTIVE.....	9
1.2 RESEARCH BACKGROUND .....	10
1.3 DATA SOURCES AND METHODS .....	11
1.4 OUTLINE OF THESIS .....	12
2. ECOSYSTEMS CLASSIFICATION .....	14
2.1 INTRODUCTION.....	14
2.2 LITERATURE REVIEW .....	17
2.3 DATA AND METHODS .....	19
2.3.1 Data collection .....	19
2.3.2 Keywords processing .....	21
2.3.3 Keywords Network Analysis .....	22
2.4 RESULTS.....	22
2.4.1 Keywords Processing and Analysis .....	22
2.4.2. Keywords Network Analysis .....	26
2.5 DISCUSSION .....	30
2.6 SUMMARY .....	35
3. CASE STUDY OF ELECTRIC VEHICLES ECOSYSTEMS .....	36
3.1 INTRODUCTION.....	36
3.2 LITERATURE REVIEW .....	36
3.3 DATA AND METHODS .....	39
3.4 RESULTS.....	41
3.4.1 Clusters of Deals Activity .....	41
3.4.2. Formation Hub Firms Profiling.....	45
3.5 DISCUSSION .....	54
3.5.1 Typology of deal strategy of hub firms and ecosystem structure .....	54
3.5.2 Country Influence.....	56
3.5.3 Value Chain Coverage and Links between Ecosystems .....	57
3.6 SUMMARY .....	63

4.	CASE STUDY OF IOT LINKED ECOSYSTEMS .....	64
4.1	INTRODUCTION.....	64
4.2	LITERATURE REVIEW .....	64
4.3	DATA AND METHODS .....	67
4.4	RESULTS.....	68
4.4.1	Clusters of Deals Activity .....	68
4.4.2	Hub Firms Profiling .....	70
4.4.3	Inter-Cluster Links between Hub firms.....	86
4.5	DISCUSSION .....	86
4.6	SUMMARY .....	96
5.	DISCUSSION AND CONCLUSION .....	97
5.1	ACCESSING LESS OBVIOUS NICHE KNOWLEDGE .....	97
5.2	FIRM ENGAGEMENT PATHWAYS .....	97
5.3	HUB FIRM ASPIRATIONS.....	99
5.4	ALIGNING WITH REGIONAL INNOVATIVE CLUSTERS.....	100
5.5	LIMITATIONS .....	100
5.6	FUTURE DIRECTIONS.....	101
6.	REFERENCES .....	102
7.	APPENDICES .....	117

## LIST OF TABLES

Table 2-1 Ecosystem Keywords co-occurring with keyword “Helix” .....	30
Table 3-1 Types of transactions involved.....	42
Table 3-2 Characteristics of Hub Firms of the largest EV linked clusters of the deals network ..	43
Table 3-3 Typology of deal intentions and strategies of hub firms .....	56
Table 3-4 Electric Vehicles Value Chain coverage of Hub Firms.....	59
Table 4-1 Types of transactions involved.....	69
Table 4-2 Characteristics of Hub Firms of the largest IOT linked clusters of the deals network	72
Table 4-3 Profile of Hub Firms of Top 5 Clusters.....	74
Table 4-4 Summary of Amazon’s functional acquisitions .....	77
Table 4-5 Summary of Intel’s functional acquisitions.....	82
Table 4-6 Summary of KPN’s functional acquisitions .....	83
Table 4-7 Assessment criteria examples for categorizing deal inclinations .....	90
Table A1 Amazon.com Minority Stake & Capital Increase Deals.....	117

## LIST OF FIGURES

Figure 1-1 Outline of the Thesis .....	13
Figure 2-1 Web of Science records related to business, innovation and digital ecosystems .....	15
Figure 2-2 Keywords Processing and Network Analysis Methodology Overview .....	20
Figure 2-3 Top keywords of Business, Innovation and Digital ecosystems domains .....	25
Figure 2-4 Ecosystems Knowledge Sharing for the Smart City domain .....	27
Figure 2-5 Knowledge Sharing for Digital Business Ecosystems .....	28
Figure 2-6 Themes of domains positioned within the ecosystem types and their overlaps.....	31
Figure 3-1 Electric Vehicles related deals trends .....	41
Figure 3-2 Deals network of Electric Vehicles (1,954 companies in 623 clusters).....	45
Figure 3-3 Electric Vehicles related Deals Activity Clusters by Hub Firm and period .....	46
Figure 3-4 Network links between Johnson Controls, Smith and Azure Dynamics .....	60
Figure 3-5 Independent EV ecosystems of Tesla and BYD .....	61
Figure 4-1 Deals trend of Internet of Things linked firms.....	69
Figure 4-2 Deals network of Internet of Things linked companies .....	70
Figure 4-3 Business Functions of Top 28 Clusters of IOT related deals.....	75
Figure 4-4 Cluster 1 – Amazon.com and Salesforce.com .....	76
Figure 4-5 Cluster 2 – HTC Corporation.....	80
Figure 4-6 Cluster 3 – Intel Corporation.....	81
Figure 4-7 Cluster 4 – Koninklijke KPN NV .....	83
Figure 4-8 Cluster 5 – PTC Inc., Itron Inc., Semtech Corp. & Orbcomm Inc.....	85
Figure 4-9 Inter-Cluster Links between Hub Firms.....	87
Figure 4-10 Hub firms positioning by Market-Oriented vs. Technology-Seeking Deals.....	91
Figure 4-11 Proportion of Market-Oriented and Technology Seeking Deals in Hub firms .....	91
Figure 4-12 Cumulative Deals of Hub Firms, Year by Year from 2005 to 2019.....	93
Figure 5-1 Perceptual positioning of firm types by deal inclinations .....	99

# 1. INTRODUCTION

Firms seeking to profit from engaging with growing numbers of business ecosystems (BE), innovation ecosystems (IE), digital ecosystems (DE) and other ecosystem related jargons, can find it to be a formidable task to differentiate among the potentially relevant ecosystems. Adding to this complexity, contributions and influence of non-firm type ecosystem entities and knowledge sharing across ecosystems needs to be factored in to further qualify which ecosystems to engage with. Due to the sheer number of linked actors serving diverse functions with varied influencing abilities, diversity and pace of interactions involved in emerging ecosystems, such an ambition is often not achievable with conventional methods.

The research contained in this thesis addresses the above mentioned challenges in framing firm strategy from a formation dynamics perspective. An ecosystem in its formation stage is likely to comprise of critical supply chain actors, but may not contain all the entity types typical to a matured ecosystem such as non-firms, complementors, intermediaries, influencers, fringe stakeholders, government bodies, universities and others. The contributions begin with deciphering themes and domains coverage in the literature bodies of knowledge of the largely exclusive and overarching ecosystem types of Business Ecosystem (BE), Innovation Ecosystem (IE) and Digital Ecosystem (DE), and their boundaries. A method to programmatically identify less obvious cross knowledge sharing opportunities contained in BE, IE and DE topics is proposed with illustrative examples. Empirically derived topics contained within BE semantically classified firm strategy as a BE topic. Anchoring BE as the focus for the deeper analysis, exploration of cross-knowledge sharing opportunities with IE and DE are suggested for inclusion in the design of alliances networks with firm and non-firm entities.

Case studies of contrasting emerging business ecosystems in their formation stages of deals making are conducted to derive firm strategies historically pursued. The BE case studies of electric vehicles (EV) and IOT linked ecosystems are selected for comprehensive breadth coverage. The global EV ecosystems are more centrally themed and competing, while IOT linked ecosystems are distributed and non-competing across diverse applications. The EV ecosystems are assessed to be competing as the actors are exclusively engaged in supplying vehicles components, services (including distributorship), assemblies and charging infrastructure and power generation for the single end user facing product type i.e. an electric vehicle. While some actors may be suppliers to multiple EV related ecosystems, each EV ecosystem competes with another at the end product level of different brand and specifications

of the vehicle. A similar deals network analysis method is applied to both the cases of EV and IOT linked firms to reveal their major clusters and associated hub firms that contributed to their ecosystems formation. The findings are collated as normalized deal inclinations, strategies and influences of formation hub firms that structurally impact the ecosystem design. For the IOT case, the deal inclinations are further categorized as market-oriented vs. technology-seeking for an understanding of their chosen approaches for capability building and market growth.

The combined insights are collated and organized in a unified firm strategy framework for engaging with business ecosystems. This framework serves as a guideline to efficiently identify relevant ecosystems to engage with, influences of other entities, approach to access cross-knowledge sharing and evaluating merits of specific positioning within the ecosystems.

Chapter 1 introduces the problem being solved, objective of this study, associated research background and the methods applied. Chapter 2 describes the keywords and their network analysis that guided the classification of the ecosystem types and knowledge sharing within them. Chapter 3 describes the EV deals network analysis that identified the formation hub firms and the basis for the systematic analysis for the strategy typography and other influencers. Chapter 4 describes the deals network of the IOT linked firms, profiles of the hub firms of the major clusters and their chosen deals portfolio in terms of market-oriented vs. technology-seeking inclinations. This is followed by a discussion and conclusions in Chapter 5 that derives insights from the combined findings, proposes a combined firm strategy framework and possible future directions.

## **1.1 OBJECTIVE**

The objective of the research contained in this thesis is to offer empirically derived heuristic strategy guidelines for firms seeking to engage with ecosystems. The heuristic approach from the facet of formation dynamics is proposed to reduce the complexity associated with the size, diversity and pace that ecosystem firms need to decipher to craft engagement strategy. The information relevant for the objective is constructed through an understanding of ecosystem types, firm and non-firm actors of an ecosystem, cross-knowledge sharing potential, strategies historically pursued by major hub firms and market vs. technology-seeking inclinations framework. Deals analysis of contrasting business ecosystems of EV and IOT linked hub firms provide the wide spectrum empirical basis to develop a unified firm strategy framework.

## 1.2 RESEARCH BACKGROUND

Literature review from academic and non-academic sources is conducted on the topics of ecosystem strategy, firm strategy, incentives for firms to engage with ecosystems and ecosystem formation dynamics. Strategy insights related to ecosystem formation dynamics are then collated from these topics to guide the approach for the research objective.

Ecosystems can offer firms new intermediary sales channels, new capability when bundling products<sup>1</sup> with complementary actors to appeal to end consumers and new products co-innovation for access beyond a firm's traditional industry boundaries [1]. Even after negating the significant impact of monopolistic regulatory pressures, it is still less likely that a single firm can service all customer needs [2]. It has therefore been suggested that ecosystem-focused frameworks are of more relevance than firm-focused ones for understanding the roles of firms and the nature of their dependencies. Various models of ecosystems competition and cooperation have been explored in literature such as component strategy, system strategy and bottleneck strategy [3]. Ecosystems can be open, managed or closed. The Symbian platform of Nokia, which is believed to have contributed to its fall, is an example of a closed ecosystem strategy [4]. Open ecosystems, on the other hand, can generate competitive advantage [5] through more easily attracting complementors. Open ecosystems such as Uber's drivers, however struggle with ensuring quality standards [6]. For an emerging ecosystem, its openness can offer merits to firms and other actors to engage with [7], however there remains a distinct possibility that many desirable complementors do not enrol. One reason for this could be the failure to identify the less obvious cross-industry and cross-discipline actors with relevant knowledge, and therefore a gap in outreach and appeal to them. Knowledge brokering has resulted in numerous pioneering innovations [8], which can benefit business ecosystems with access. The research in this thesis presents a programmatic approach to identify such knowledge within ecosystems in the form of topics and domains related to a targeted topic of interest.

Conventional firm level strategies include evaluation of merits of upstream integration, downstream integration, portfolio expansion, new market entry and hedging against technological threats. When applied over an emerging ecosystem landscape, the degree to which firms engage with ecosystems can vary based on their perceived risks. The regulatory

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<sup>1</sup> References to "products" in this thesis considers both products and services, and their varying degrees of integrated business offerings.

environment, country incentives [9] and access to complementary technologies [10] are additional influencers for strategy choice. A challenge in gathering evidence to select a certain conventional firm strategy is the sheer numbers of interlinked ecosystem actors to include. Programmatic methods for ecosystem mapping techniques have been utilized for such purposes to identify gaps in company, competitor, customer and category ecosystems respectively [11]. Ecosystem mapping methods though valuable due to use of empirical sources, currently require human expertise with specialized software system capability and can be hard to interpret for actionable strategy insights [12]. Intuitive heuristics based guidelines derived programmatically from empirical studies offer certain advantages that overcome the complexities described.

This study has focused on formation stages of ecosystems to derive the heuristic guidelines. During the formation stages, successful deals-making with critical suppliers and non-firm actors like specific government bodies are more visible publicly to motivate other ecosystem entities to enrol. Deals involve financial transactions and public declarations of commitment for ecosystem formation and therefore more credible evidence as compared to press releases stating intention and other market signals.

### **1.3 DATA SOURCES AND METHODS**

The phased research in this thesis comprises of ecosystem classification, case studies of EV ecosystems and IOT linked ecosystems. For all the phases, independent literature survey is conducted in Section 2.2, Section 3.2 and Section 4.2. For ecosystem classification, academic articles retrieved from Clarivate Analytics Web of Science Core Collection are used to conduct keyword network analysis as described in Section 2.3. For both the case studies of EV and IOT linked ecosystems, a similar method of deals analysis is used. Data for the historical deals is sourced from Zephyr Database of Bureau van Dijk Electronic Publishing (BvDEP) that lists global M&A, IPO, and Private Equity deals, which has been used in a number of academic studies. The deals data from Zephyr is available in a standard data format that is suitable for text mining and analysis. The deals analysis is conducted using the Louvain algorithm that revealed major clusters and their respective hub firms. Details of the method used for the deals analysis is described in Section 3.3 and Section 4.3. Various parameters of the deals such as deals type, deals status, acquirer and target profiles and rationales of the deals are analysed and compiled in tables and charts using spreadsheets.

## **1.4 OUTLINE OF THESIS**

The organization of this thesis is illustrated in Figure 1-1. Chapter 1 provides an overview of the need for ecosystem firm strategy guidelines, objective of this study that addresses the need, the associated research background and the empirically derived methods utilized to achieve the objective. Chapter 2 identifies the primary ecosystem types as business, innovation and digital ecosystems and using keyword analysis proposes their respective definitions and knowledge sharing opportunities amongst them. To cover the breadth of ecosystem firm strategies, two contrasting case studies are conducted. Chapter 3 describes the case of the centralized and competing ecosystems that formed the global electric vehicles industry. Chapter 4 describes the case of the distributed and non-competing IOT linked ecosystems. Finally, in Chapter 5, the findings are discussed and combined in a unified ecosystem firm strategy framework.

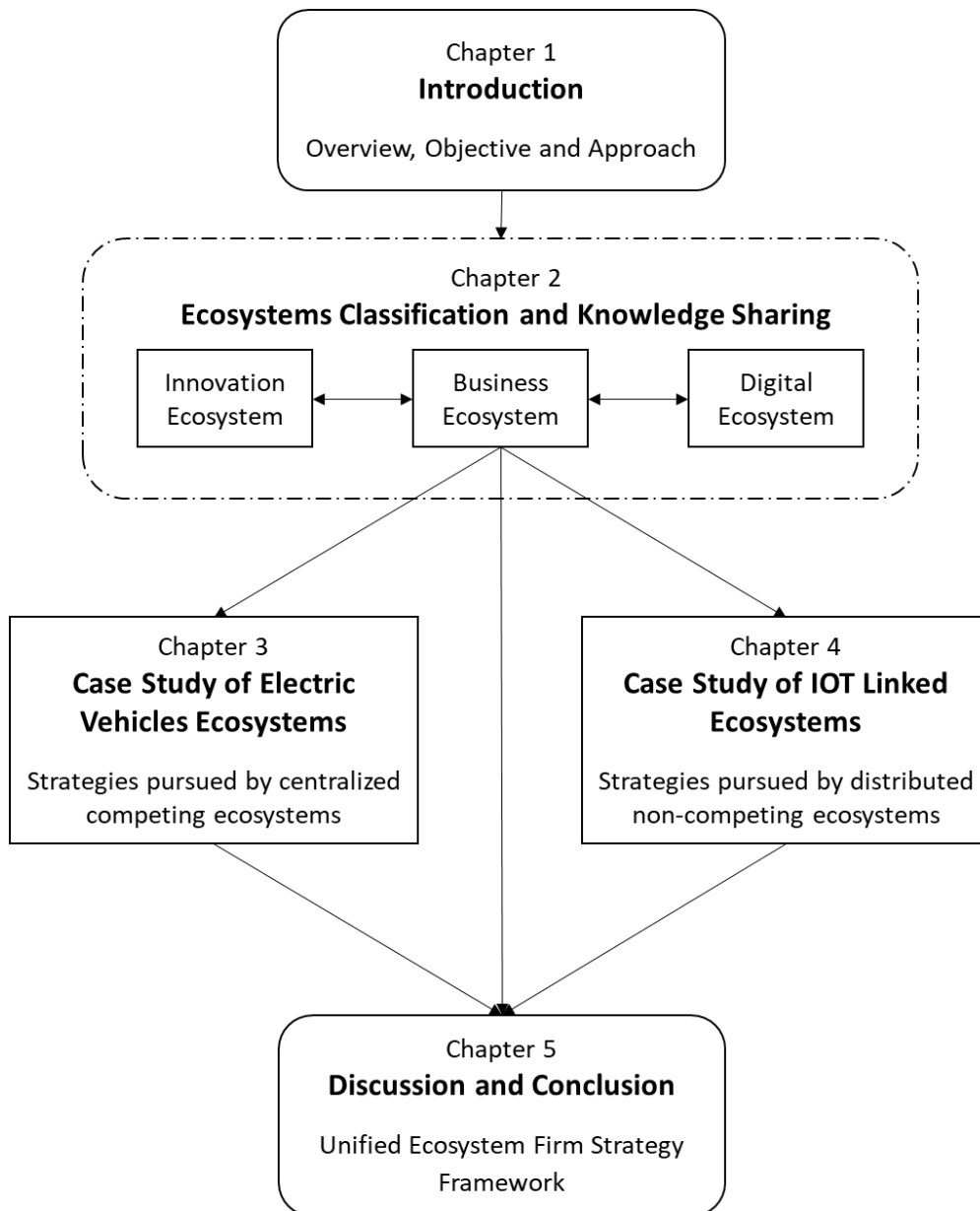


Figure 1-1 Outline of the Thesis

## 2. ECOSYSTEMS CLASSIFICATION

### 2.1 INTRODUCTION

Business Ecosystems related literature is growing rapidly in recent years. Per Web of Science Core Collection, the number of records increased steadily from 5 per year in 2004 to 70 per year in 2017 to a total of over 600 records. Industry sources are linking renewed interest in business ecosystems due to advances in digital technologies [13]. Despite increasing interest on the concept, its meaning is not well-sophisticated and even confusing. The differences between business ecosystems and semantically related concepts like digital ecosystems, innovation ecosystems, digital innovation ecosystems, hub ecosystems, open innovation ecosystems, platform-based ecosystems, knowledge ecosystems and their variants have not been clearly articulated.

Digital ecosystems can semantically and intuitively even be interpreted as a context or application or a mode of technological execution of both innovation and business ecosystems. Such an ambiguity hampers efficient access and relevant utilization of these “concepts”. Several highly cited articles on business ecosystems in turn cite articles on innovation ecosystems that do not appear in the results of scholarly articles search on business ecosystems. An example of such as case is the seminal article by Prof. Ron Adner on innovation ecosystem strategy [14] that does not contain “business ecosystems” as an author keyword and is also not present as a word in the title, abstract and main body of the article. A distinct possibility is that the vocabulary used by authors when crafting the title and abstract of the papers might unintentionally separate fields of study that are semantically or contextually connected. The earliest reference to the term “Innovation Ecosystem” were in relation to regional technological innovation ecosystem [15]. The observation that “business ecosystems” are related to “digital ecosystems” and “innovation ecosystems” motivates an exploration of a more quantifiable approach to understand their inter-relationships.

Out of the top 500 most cited articles in Web of Science Core Collection on the topic “business ecosystem” from 1993 to March 22, 2018, 276 articles do not include a reference to the keywords “digital ecosystem” and “innovation ecosystem” in their titles and abstracts. A more detailed search with the various combinations revealed a rather narrow overlap between the three ecosystems (Figure 2-1) with a sizable contribution of 433 articles on “innovation ecosystems” and 403 articles on “digital ecosystems” as compared to 541 articles on “business ecosystems”. This search result has offered evidence that “digital ecosystems” related literature

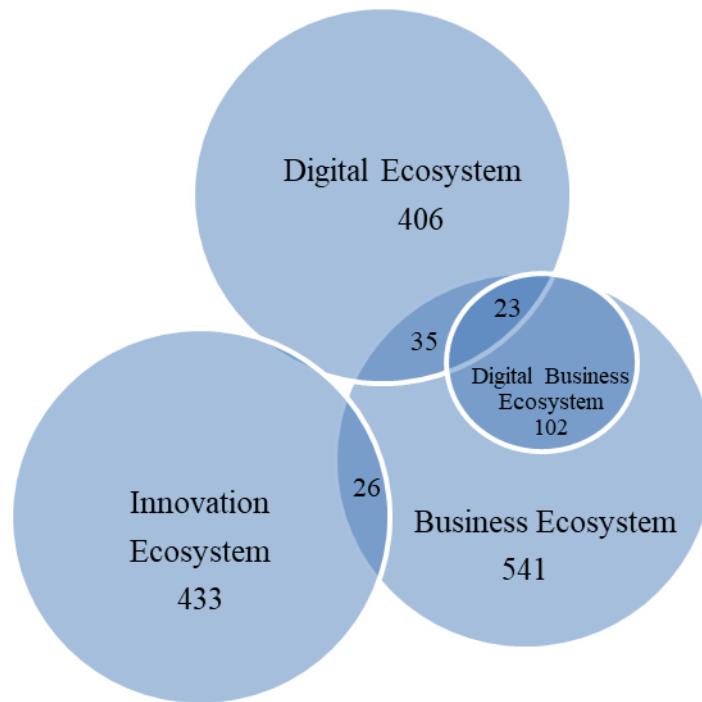


Figure 2-1 Web of Science records related to business, innovation and digital ecosystems (retrieved on March 22, 2018)

has evolved rather independently and not as a subset of the other two. It is yet to be seen if the three concepts will merge more in future as a unified body of knowledge, or more distinctly differentiate with inter-dependencies.

To identify if there are any other dominant non-biological ecosystem types, we conducted a quantitative analysis of literature that references various 2 or 3 word domain keywords that contain the word “ecosystem”. We extracted these multi gram words from titles, abstracts and assigned keywords of 266,663 articles for the years 1993 to 2019 and ranked their frequencies of mentions. On removing generic, function specific, non-coherent, sector specific and biological related keywords that were mentioned over 300 times over the time period, we found that “business ecosystem” ranked the highest with 1,130 mentions, “innovation ecosystem” ranked 2nd with 1,064 mentions and “digital ecosystem” ranked 3rd with 783 mentions. Among other qualified ecosystems with over 300 mentions, we found over 100 articles each on “software ecosystems”, “information ecosystems” and “data ecosystems”, all overlapped with “digital ecosystems” with 1 to 3 articles as exceptions. “Entrepreneurial ecosystems” ranked 5th with 553 mentions and all 183 articles with the mentions were found to be fully overlapping with “business ecosystems” or “innovation ecosystems” or “digital ecosystems”. Articles on “Industrial Ecosystems” with 438 mentions ranked 6th also overlapped fully with “business ecosystems” or “innovation ecosystems” or “digital ecosystems”. “Knowledge

ecosystems” ranked 9th with 377 mentions and out of 87 articles found, 70 did not overlap with either “business ecosystems” or “innovation ecosystems” or “digital ecosystems”. Out of these 70 non-overlapping articles, only 10 were cited over 5 times by Web of Science Core Collection. The distinctly most cited article (93 times) related to knowledge ecosystems by [16], overlapped with “business ecosystems” and therefore included in this study. Within the “knowledge ecosystem” related articles, 9 articles contained reference to “digital knowledge ecosystems” which did not overlap with “digital ecosystems”, though they can be considered to be semantically related. While this evidence and the semantic distinction could support the case of including “knowledge ecosystems” as separate emerging ecosystem related knowledge body for further investigation, due to the relatively smaller count of highly cited articles, it is excluded from this study and rather included as a limitation.

For an additional evaluation of popular ecosystem type terms, the data set selected in Figure 2-1 was additionally verified to include all articles related to “digital innovation ecosystems”, “hub ecosystems” and “open innovation ecosystem”. When using the search keyword “platform ecosystem”, we found 78 articles, all of which overlapped with either “business ecosystems”, “innovation ecosystem” or “digital ecosystem”. We have additionally verified that articles related to variants of “platform” such as “platform-based ecosystem”, “platform leader” and “platform strategy” are included in the data set used for this study. Based on the above analyses with keywords commonly associated with non-biological ecosystems, we propose that BE, IE and DE are the primary prevalent references and therefore the focus of this study.

Several definitions of business, innovation and digital have been offered in literature, with Moore [17] [18], Iansiti and Levien [19], and Power and Jerjian [20] being the prominent ones. Several other authors have compared, merged, revised and interpreted the definitions [21]. Business Ecosystem (BE) specifically has been defined in multiple ways and has been used interchangeably by some with innovation ecosystems (IE) [22] as well as jointly categorized, including with digital ecosystems (DE). This current lack of clarity between the distinctly evolving major non-biological ecosystem linked references makes it difficult to differentiate, consolidate and utilize the body of knowledge both in academia and industry.

This study reports on topics associated exclusively with either IE, BE or DE and combinations of their overlapping occurrences. Based on certain consistencies observed in the assigned topics, a contextual association of IE, BE and DE as “Science, Technology and Policy”, “Actor, Network and Strategy” and “Digital Technology” is suggested. On deeper characterization of overlapping topics, we identified certain distinct bodies of knowledge that

share knowledge with other theories, applications and technologies. Some topics over time may continue to grow in the presently observed characterization or may converge [23], spin-off in new trajectories [24] or get superseded. The findings in this study offer a baseline and early insight into ecosystem related bodies of knowledge and attempt to aid in finding and publishing. In addition, the findings can promote planning of collaborations for interdisciplinary projects and policy making.

## **2.2 LITERATURE REVIEW**

Ecosystem as a concept related to business strategy and operations has been explained through multiple analogies, namely, biological ecosystem, industrial ecosystem, economy as an ecosystem, digital business ecosystem and social ecosystem [21]. Different terminology has been used to define business ecosystems such as interacting stakeholders for economic purposes [17] or mutually supportive stakeholders [18] or interconnected stakeholders [21] or the more recent integrated definition as “an independent network of self-interested actors jointly creating value” [25]. There have been variations in breath of stakeholders with the trend being more inclusive to indirect, complementing [26], influencing and fringe actors [27]. Similar efforts on defining innovation ecosystems have been made, though this term has been generally associated with new technology and processes [28] rather than matured existing businesses with large external supply chains. Under the banner of “innovation ecosystems”, group dynamics has been analyzed suggesting higher innovation performance and trust derived from triads with defined activities of a series of interlinked dyads as compared to independent dyads and single unified triads [29]. Digital Business Ecosystems were coined for software SMEs for an European Union initiative [30]. References to digital ecosystems have been mostly from an engineering perspective and specifically in relation to computing architecture [31]. Without distinguishing between the ecosystem types, the ecosystem concept has been proposed to be unified under realization of a focal value proposition that is supported through an alignment structure and affiliation between partners [32]. Building on this insight on ecosystem thinking, another seminal ecosystem-type agnostic study proposes that (successful) ecosystems are enabled by a specific set of actors with multilateral and non-generic modularities or complementarities that not fully hierarchically controlled and bound by collective deployability [33]. Both these ecosystem-type agnostic studies have been concerned with monetization and used firms as examples, suggesting that their contribution is more relevant to business ecosystems.

Importance of cross-domain knowledge sharing in early product-service design systems as proactive knowledge management has been elaborated and divided between explicit and implicit knowledge [34]. This body of knowledge mostly residing in firm level strategies of supply chain and service providers, can be extended to relevant knowledge contained in related ecosystems. Publicly available academic literature for such cases would be traditionally considered to be explicit knowledge. However, there is an implicit aspect to it aided by bibliometric methods that can reveal relevant cross-domain knowledge, The emerging field of cross domain collaborative filtering and associated recommender systems has also focused on firm level guidance [35] and has classified the algorithmic based scope to system, data and temporal systems [36]. Applying collaborative filtering concepts to academic literature for finding historical knowledge applicable to address unsolved industrial problems, would be an aid to contribute to this discipline.

Scholars have studied business ecosystems from a diverse range of topics which include strategy [37], competitiveness [38], cooperation or collaboration [18] [39], supply networks and other stakeholders' networks [40], sustainability [41], open innovation [42], platform management [43], intellectual property [37], complementarities [28], capabilities [44], university-industry alliances [45], new ventures [46], spin-offs [47], policy making [48] and boundaries of an ecosystem from conceptual, structural and temporal considerations [49]. Business ecosystems related articles have also addressed analogies with biological ecology, alliance clusters and business symbiosis [50]. Two articles have specifically dealt with the total landscape of business ecosystems. Graca et. al [51] discussed performance indicators for business ecosystems using literature review and classified business ecosystems as a collaborative networked organization with long-term strategic intent that includes virtual elements. They additionally demonstrated that a number of contributions to business ecosystems can be found in several research fields such as enterprise performance indicators, collaboration benefits, value systems, supply chain collaboration, and social network analysis.

Technology Forecasting and Social Change Journal recently recognized the growing importance of ecosystem literature and dedicated a special section on Innovation Ecosystems: Theory, Evidence, Practice, and Implications in Volume 136 dated November 2018 [52]. Out of the 16 articles in this group, 2 were found relevant to this study. The first article authored by Tsujimoto et al. [53] has classified business related ecosystems into four perspectives, namely, industrial ecology, business ecosystem, platform management, and multi-actor perspectives. They also presented an integrated model of previous related research. The second article authored by Gomes et al. [54], a bibliometric study, that has attempted to reveal

boundaries between BE and IE and to the best of our knowledge is the closest to the objectives of our study. Gomes et al. have used a combination of citation, co-citation analysis and cross-citation analysis on academic articles on the two ecosystem types. Citation analysis was used to develop the keywords network of most cited articles (authors, journals, time scale) and articles-to-reference network. Co-citation analysis results were used to propose topic names of fields. Turning point network analysis by authors traced the maturity of the terms or domains from business ecosystems to innovation ecosystems from the year 1993 onwards. An implied suggestion of this turning point analysis is that the “business ecosystems” domain is being replaced in popularity by “innovation ecosystems”, though this claim cannot be fully supported due to the growing annual numbers of publications on business ecosystem. Additionally, content analysis was conducted on a shortlisted list of articles from where five research streams characterizations were recommended.

This study by Gomes et al. diverges from ours in coverage, methodological approach and scope. In addition, our study includes literature on digital ecosystem to explore possible overlaps with the other two ecosystem types [21]. We applied text mining techniques that cover the entirety of documents under study, revealing exclusive and overlapping terminologies, and research topics at a deeper level that might be overlooked by human judgement. We contribute to defining contemporary domains and to the field of cross domain knowledge sharing and collaborative filtering for academic literature.

## **2.3 DATA AND METHODS**

The methodology adopted in this study comprises of three stages as illustrated in Figure 2-2. First we collected academic articles for each of the three ecosystem domains under study i.e. BE, IE and DE. Second, each set was processed to reveal commonalities and differences in the terminology used in author keywords, titles, and abstracts of papers. Third, a keywords network analysis was conducted to identify co-occurrences of keywords representing domains to reveal knowledge sharing between the ecosystems. Details are explained in the following sections.

### *2.3.1 Data collection*

Academic articles were retrieved from Clarivate Analytics Web of Science Core Collection. This is a bibliographic database collecting articles from more than 20,000 publications including journals and academic conferences [55]. It is known for a higher quality standard

when indexing journals, making it a reliable source of information. It also structures the data in a format suitable for data mining purposes, a property that has been leveraged by several bibliometric studies [56]. To gather the data, we used a topical search for each of the following keywords “business ecosystem\*”, “innovation ecosystem\*” and “digital ecosystem\*”, where the asterisk is a wild card for their plural and singular instances. We collected 545, 150 and 406 articles respectively for each set for all the years available up to March 22, 2018 (the date of retrieval).

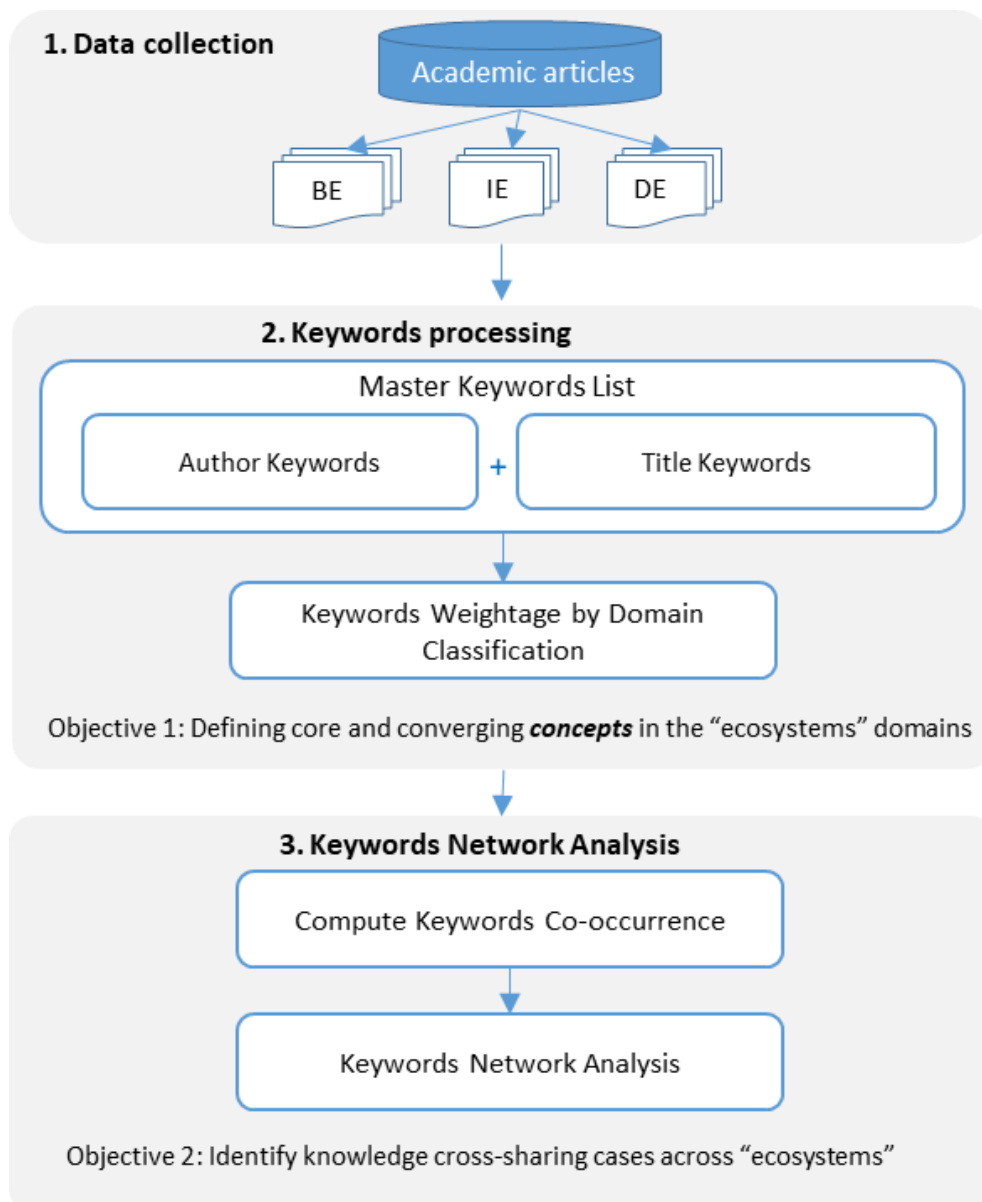


Figure 2-2 Keywords Processing and Network Analysis Methodology Overview

### 2.3.2 Keywords processing

To identify the vocabulary used in each of the domains, we searched for words and phrases that define every article in the datasets. For each article, we collected the author keywords and complemented them with the Web of Science Keywords Plus field. The latter has been found to be as effective as author keywords in defining the structure of scientific literature [57], with the added benefit of being present even for articles in journals that do not require the authors to submit keywords. We called this combined set as “Author Keywords”. For added comprehensiveness, we also searched for additional common occurrences of 2, 3 and 4 words-long phrases in the titles and abstracts. We conducted this search programmatically by feeding the text to a Markov-chain based algorithm that mapped the content with multiple occurrences of n-grams [56]. For each article we took one instance of every n-gram that appeared two or more times in the article and we called this set as “Title Keywords”. We then combined the “Author Keywords” and “Title Keywords” to compile a “Master Keyword List”. This step was performed using common data cleaning practice such as removing punctuation, numbers, and stopwords. We also stemmed the keywords to facilitate the matches regardless of singular, plural or verb conjugation variations. This “Master Keywords List” took the form of a data frame having rows for each of the keywords and the number of articles that contain that keyword by ecosystem type. A further cleaning step was conducted to remove all keywords that appeared less than 5 times, along with a manual inspection to retain only nouns, names and titles and complete expressions or phrases and removal of redundant, abbreviated or common terms (see Appendices List A1). For reporting purposes, the stemmed keywords were transformed back to their natural language equivalent.

Following this data preparation, instead of using keywords counts, we transformed them into proportions. This served as a weightage score for ecosystem type for each keyword. We then identified exclusive and overlapping keywords as described in the steps below:

- Domain exclusive keywords: Those that appeared only in one of the datasets, (i.e. having a weight = 0 in the other datasets)
- Overlapping keywords: Those that appeared in two datasets (i.e. having a weight = 0 in the remaining dataset)
- General keywords: Those with occurrences in each domain

### 2.3.3 Keywords Network Analysis

While the above process serves to elucidate the domains related to the three ecosystems and their boundaries, it does not provide insight into inter-relationships between them. Such an insight would serve to better define cross-knowledge sharing between the ecosystems. For this purpose, keyword co-occurrence network analysis is conducted, where each keyword in the master list acts as a node connected to other keywords when they co-occur in a single document. The linkage between 2 keywords is generally stronger when they co-occur in several documents, implying that they are more topically related. Keyword co-occurrence networks tend to be dense, meaning that domain keywords might get connected to most of the other keywords in the list because they naturally appear in most of the articles. In addition, pairs of keywords might co-occur only once producing less relevant linkages. To overcome such shortcomings, a data preparation step is conducted to remove nodes connected to 50% or more of the rest of the keywords to remove common keywords. Also, we removed edges between those pairs of words that only co-occurred in one document. With the network pruned, we found groups of keywords tightly related by applying a community detection algorithm [58]. As a final output, we obtained a network of keywords in which each is associated to an ecosystem domain as well as to a community cluster.

Using this above described pruned network, we focus on keywords that are more clearly differentiable to reveal cross ecosystem knowledge sharing. The criteria selected for this purpose is described below:

- Which connections are more spread across the BE, IE, DE and their overlaps
- Belong to a community of 5 to 15 keywords. (i.e. disregarding smaller clusters)
- Those belonging to generic clusters. (i.e. the cluster is composed of synonym words)
- Those that serve as a hub to larger topics. (e.g. between “living labs” and the connected domain of “smart city”, “smart city” is selected due to a larger relative network size)

## 2.4 RESULTS

### 2.4.1 Keywords Processing and Analysis

The core domains that are exclusive to the ecosystems and related overlapping and general keywords were identified and mapped in Figure 2-3. The “Master Keywords List” contained 818 keywords, out of which 201, 255 and 155 keywords based on occurrence frequency could

be located purely within BE, IE and DE articles as domain exclusive keywords. We also identified 543 overlapping in IE and BE, 419 in BE and DE and 429 in IE and DE. 38 general keywords appeared in all three IE, BE and DE. Figure 2-3 illustrates the top keywords positioned in a tripartite framework, as exclusive by ecosystem type or overlapping across the ecosystems.

Exclusive keywords in BE are shown on the top of Figure 2-3. The central concepts in BE are business actors and networks. Their related keywords are trusted agent, customer engagement and value network. Another dominant concept is strategy, with its corresponding keywords being platform strategy and platform leader. Network and strategy are vital factors affecting firm performance. Other keywords are more closely related to DE rather than BE, e.g., mobile network, mobile internet and digital business ecosystem. Some keywords are case-related which include electric vehicle industry.

In IE, exclusive keywords consist of those on science, technology, and policy. Examples of technological keywords from Figure 2-3 are digital health, science parks, food engineering, human smart cities, precision medicine, and genome medicine. In addition to science and technology, technology transfer, basic research, and learning process are also studied. University and entrepreneur play important roles. Policy and managerial keywords such as science parks, regional cluster, brand communities, and intellectual capital also appear. In DE, exclusive keywords comprise more of digital technology components. Such topics include information retrieval, virtual reality, power consumption models, and applied gaming. There are several keywords on 'soft' aspects of ecosystems, e.g., service, user, and culture. Examples of such frequently occurring keywords are service ecosystem, service composition, user model, collaborative environment, consumption model, copyright law, and cultural heritage.

In Figure 2-3, we also show boundary topics. At the boundary of IE and BE, a central issue is to deliver science and technology from IE to BE. The associated keywords are new venture, technological entrepreneurship, open data and industrial cluster. Open innovation and strategic management to design competitive advantage are also present. Social issues and public concerns like sustainable development, developing countries, emerging industries, economic development, circular economy also occur within this boundary.

At the boundary of BE and DE, most of keywords are related to information system. The keywords include social media, enterprise architecture, and cloud computing. We can also see service-oriented business issues like web services, service provider and service-oriented architecture. These information system and service related topics might be a key driver for dynamic capabilities in collaborative network and thereby suggesting that digital

transformation is necessary for the development of digital business ecosystems. Between IE and DE, we can see virtual and social systems of IE like living labs, social capital, social economics, knowledge transfer and data science. Cyber physical system also appears here.

General keywords occurring in each domain include cutting-edge domains and case studies of ecosystems including smart cities, Big Data, ICT and IoT. Other dominant ones that are related to the orchestration of ecosystems are competition, collaboration, knowledge creation, knowledge sharing, knowledge management, communication technology, collective intelligence, and collective action. These general keywords collectively represent a knowledge inputs to the ecosystems.



Figure 2-3 Top keywords of Business, Innovation and Digital ecosystems domains

#### 2.4.2. *Keywords Network Analysis*

The network filtering criteria as described by method in Section 3.3 revealed certain distinct larger or central domains which co-occur with others across the three ecosystems. The more prominent occurrences of knowledge sharing are described below. In the following sections, we select typical keywords and illustrate how each keyword is related with other co-occurring keywords. We select “smart city” as a typical keyword of general keywords, “digital business ecosystem” from overlapping keywords, and “helix” from domain exclusive keywords.

##### 2.4.2.1 Smart City Conceptualization and Implementation

Smart city is one of the prominent keywords whose co-occurrence network includes diverse nodes that are widespread among BE, DE, and IE. Definitions of Smart City include municipality and multi-stakeholder partnerships using technology based solutions and especially Information, Technology and Communication (ICT). The objective of the alliances is to efficiently and sustainably improve the quality of government services and citizen welfare with a key component of information sharing with public [59]. When an “ecosystem” lens is applied to literature on Smart Cities, we can therefore expect it to include knowledge related to networking in research, communities, businesses and technologies.

The specific co-occurring domains revealed by the method applied are illustrated in Figure 2-4. The keywords “Co-Design”, “Building Blocks”, “Behaviour”, “Virtualization”, “Citizen Communities”, “Co-Creation” and “Cities” represent general and semantically comprehensible domains or concepts. “Human Smart Cities” concept offers people or human actors more prominence over technology for the same goal of urban "smartness" [60]. The keywords “Devices”, “APIs”, “Web” and “IoT” are general digital enablers, including APIs that are methods of communication between various components. “Open Innovation” and “Open Data” are broad approaches and part of the open initiatives for partnerships and reuse of public sector data for aiding the Smart City concept. “Living Labs” that are positioned within IE and DE offer insights into innovation aided by virtual networks by Public Private Partnerships (PPP) where firms, government bodies and citizens collaborate to design and test new services, businesses, markets and technologies in real-life contexts [61]. “Interoperability” while initially defined for the ICT sector to facilitate information exchange across different systems [62], in a broader definition considers social, political, and organizational factors that impact system to system performance [63]. “Semantic Web” is an extension of the World Wide Web

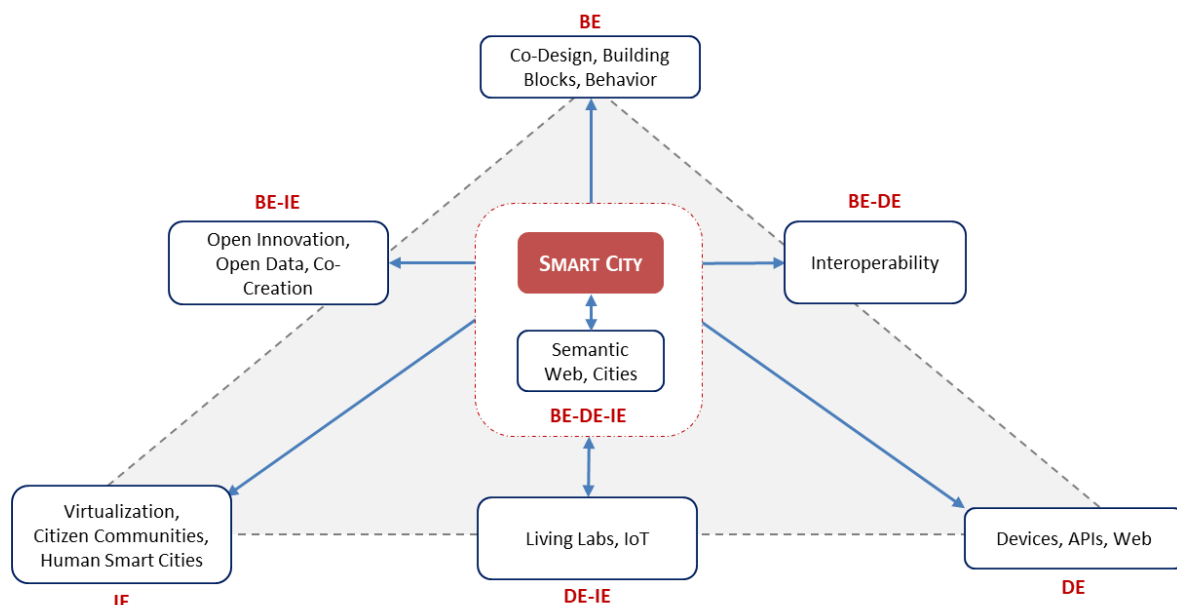


Figure 2-4 Ecosystems Knowledge Sharing for the Smart City domain

that brings structure and meaningful content to web pages designed for humans (rather than computers) to read or interpret and apply more easily. These standards developed and maintained by World Wide Web Consortium (W3C) promote common data formats and exchange protocols on the Web to facilitate integration across different content, information applications and systems [64].

#### 2.4.2.2 Digital Business Ecosystem (DBE), Trust and Agent

Digital Business Ecosystems (DBE) literature appears as a subset within Business Ecosystem literature and includes a portion of its overlap with Digital Ecosystems (see Figure 2-5). This is semantically positioned appropriately and suggestive of an emerging distinct sub-domain. DBE is a paradigm started in Europe for improving SMEs efficiency through use of ICT for collaboration with seamless interoperability [65] [21].

Several co-occurring keywords related to DBE that were general, redundant and more obvious were eliminated based on the below criteria.

- General yet qualified keywords e.g. business environment, business services, quality, ecology, university, consumer, simulation, etc.
- Ones directly or contextually supporting the general definition terms of DBE e.g. Europe, SME, cooperation, regional development, automation, business processes, etc.

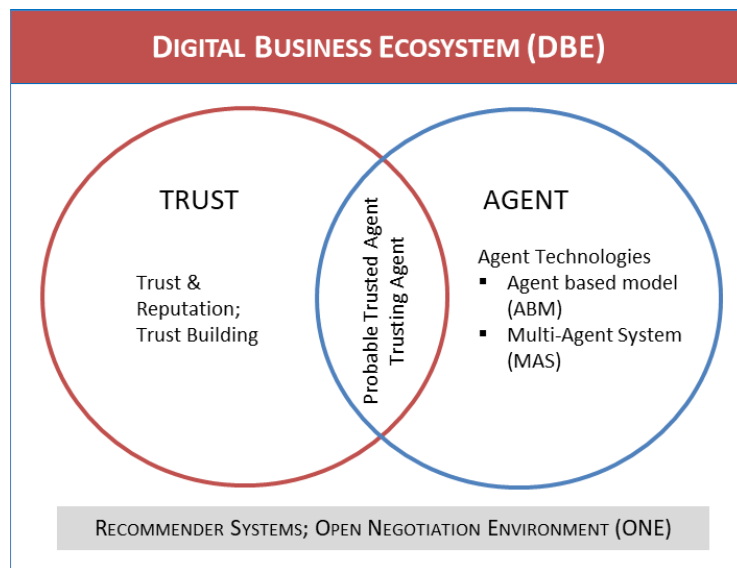


Figure 2-5 Knowledge Sharing for Digital Business Ecosystems

- Commonly expected digital technology related yet qualified keywords e.g. security, web, e-business, information systems
- Digital technology for enabling collaboration e.g. service-oriented architecture, APIs, personalization, interoperability, ontology, GIS, etc.

The resulting co-occurrences with the central theme of DBE brought forth the key concepts of “agent”, “trust”, “recommender systems” and “open negotiation environment” as associated concepts (see Figure 2-5). The reference to “agent” in DBE context implies software agent. Agent technologies are computer programs that use artificial intelligence to learn and automate certain procedures and processes. Agent-based Modeling (ABM) is a simulation technique that assesses the effects on a system due to actions and interactions of autonomous agents (both individual and collective entities such as organizations or groups) [66]. The goal of ABM is to observe collective behavior rather than problem solving. The other agent technology related to DBE is Multi-Agent System (MAS) where the computerized system is composed of multiple interacting intelligent agents to solve specific problems [67].

Trust in the context of DBE refers to the interaction of a “trusting agent” who attempts to assess the possible risk in interacting with the “probable trusted agent”. The possible risk is a combination of the probability of failure and the possible consequences [68]. Various parameters such as cultural norms and benefits / utility impact trusting behavior and service composition [69]. “Open Negotiation Environment (ONE)” is an open-source platform that

allows agents on behalf of small companies to negotiate and use the ecosystem services through technologies that enrich learning and optimize capabilities to dynamically compose complex services [70]. Scale of SME offerings for negotiations for alliances may be in millions [71]. “Recommender Systems” are software tools and techniques that provide suggestions or ratings to a particular user to aid in deciding on offerings e.g. movies, music, experts, collaborators, etc. This guidance can be in the form of content-based, collaborative and hybrid recommendation approaches [72].

#### 2.4.2.3 Helix – Triple, Quadruple and Quintuple

Keyword “helix” classified under Innovation Ecosystem (IE), is a Web of Science (Keywords Plus) generated or system generated keyword having no significance by itself in context of ecosystems and refers mostly to “Triple-Helix” and “Quadruple-Helix” and in a few articles also as “Quintuple-Helix”. “Triple Helix” is a term coined for a set of interactions between academia, industry and governments to foster economic and social development [73]. A typical outcome of such an initiative is creation of hybrid organizations such as technology transfer offices in universities, firms and government research labs, and business and financial support institutions such as angel networks and venture capital for new technology-based firms. With the added dimension of ‘society / civil participants’ or ‘media-based and culture-based public’ and ‘civil society’, it is termed as “Quadruple Helix”. With the fifth dimension of ‘natural environments of society’ such as the case of global warming [74], it is termed as “Quintuple Helix”. Table 2-1 lists the keywords co-occurring with the umbrella domain term “helix”. The relationship to innovation policy, economic development, innovation system, commercialization, entrepreneurship, university and application to cities, clusters and regional innovation are contextually related to the helix models definition. Open Innovation is integral to the helix models. Multiple definitions of System of Systems (SOS) exist, one being “large scale concurrent and distributed systems that are comprised of complex systems” [75] [76]. In context of association with helix models, such systems are also integral to execution of initiatives. “Smart Specialization”, a place-based approach and broad view of innovation and entrepreneurship with wide stakeholder involvement [77] [78], fits well with helix models goals.

Table 2-1 Ecosystem Keywords co-occurring with keyword “Helix”

Category	Keywords
BE	clusters
IE	smart specialization, quadruple helix, innovation system, university, Europe, commercialization, regional innovation
DE	system of systems, web
BE-IE	open innovation, entrepreneurship, economic development, innovation policy
DE-IE	-
BE-DE	-
BE-DE-IE	social networks, cities

## 2.5 DISCUSSION

The core objective of the ecosystems classification study is to attempt a fact-based high level themes coverage in literature of the domain of "business ecosystems" and its related domains of "innovation ecosystems" and "digital ecosystems", their boundaries and knowledge sharing opportunities within them. Previous attempts to categorize included examples such as “BE introduces the customer (demand) side, while IE focuses on technology activity” [16]. However, based on our analysis, it is more straightforward and justifiable to apply the term IE to related topics on science, technology and policy, and BE for actor, network and strategy. In a similar fashion, based on top keywords in ecosystem literature, representative themes are suggested in Figure 2-6 for the seven buckets of the domains and their boundaries as illustrated in Figure 2-3. BE encompasses topics related to actor, network and strategy. They include actors and their roles and trust amongst them, various networks including domain or industry specific networks and strategies for governance, growth and sustenance for combined value capture. IE topics deal with the theme of science, technology and policy that include research that impact regions and communities such as smart specialization, digital health, food engineering, IP, human smart cities and others. DE topics cover a broach range of digital technologies. Collaboration between BE and IE is primarily around development of physical systems including open innovation and societal related developments. Collaboration between BE and DE are broadly around development of cyber systems such as digital information and service systems. Collaboration between IE and DE are around conceptualization and operationalizing cyber-physical systems that include topics such as living labs, social capital, knowledge transfer, innovations around digital health and others. The theme where BE, IE and DE converge is knowledge and orchestration of ecosystems that include smart cities, IOT, social networks, big data, knowledge management, supply chain, open source and others. This

classification reduces ambiguity surrounding the prevailing ecosystems concepts and specifies contributing domains in a credible manner.

In addition to explicit clarifications, this study offers a different approach to finding opportunities for designing comprehensive solutions for targeted ecosystem domains. As an example, advancement in interconnected and interoperable devices under the paradigm of Internet of Things (IoT) is a known technology focus area for the Smart City vision implementation. Such a view however only captures DE and BE. Living Labs located at IE-DE boundary and engagement of citizens for human compatible designs offers the additional opportunity of sourcing relevant Big Data to guide phases of Smart City implementation for

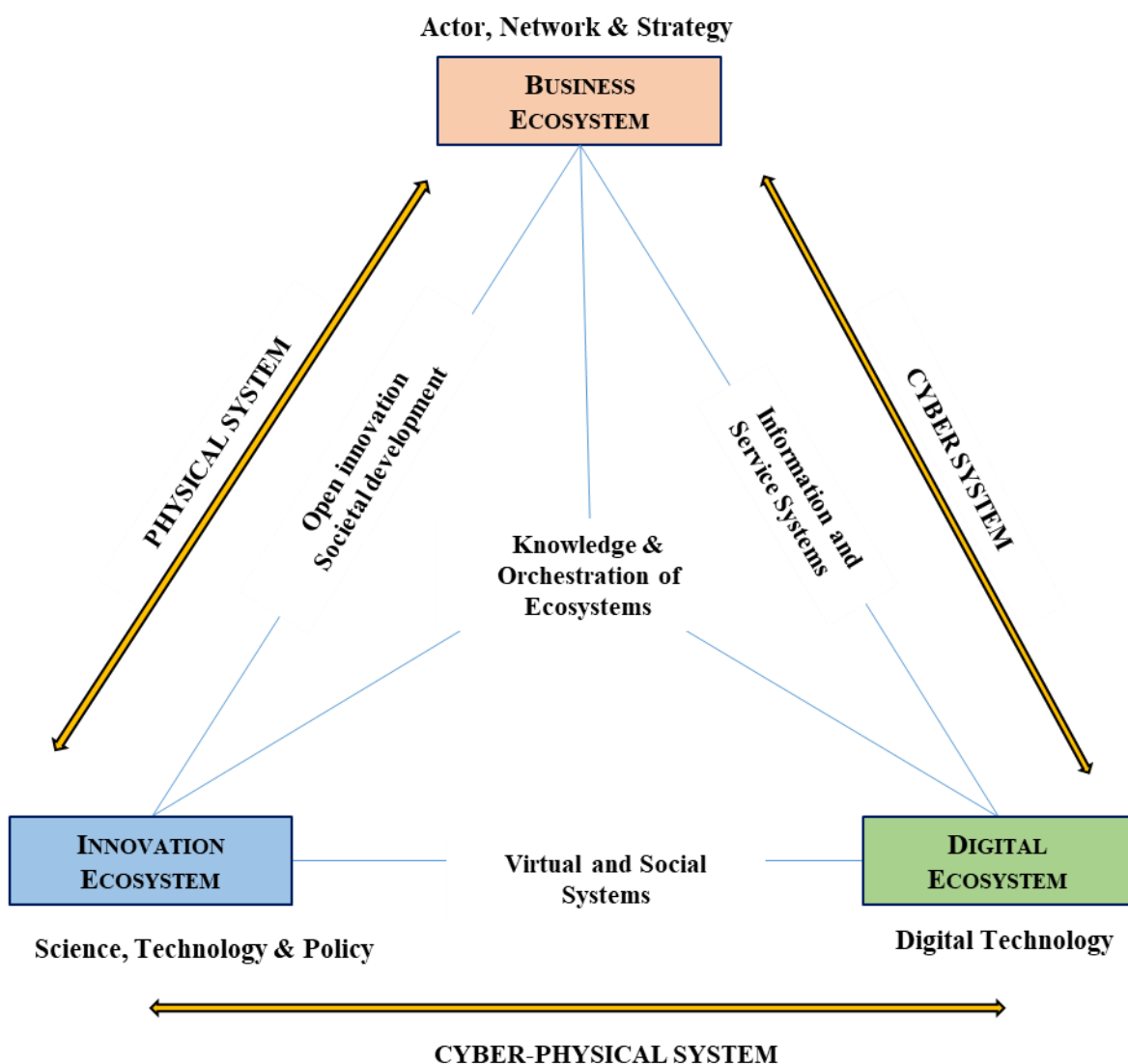


Figure 2-6 Themes of domains positioned within the ecosystem types and their overlaps

scenarios where typical innovation diffusion ingredients are in place. For the applications of Digital Business Ecosystems (DBE), a known focus area in the currently matured e-commerce era is the use of (software) bots or agents to replace less efficient human interfaces. A major concern around this widely anticipated system transition is security and reliability. It is therefore easily comprehensible that heightened academic activity is around digital trust and appropriate agent technologies. The inputs, implementation guidelines and outputs listed in the findings from initiatives under the “helix” banner are also easily validated.

There are several limitations in the approach used to classify ecosystems. The first one is a quality concern of the dataset used due to its contents being in a nascent stage of research when consensus on keywords may not been arrived at by the concerned academic community. In other words for the context of this study, there could exist a possibility that in the initial period when ecological principles were applied to business and innovation there was lack of adequate keywords expressing the related research topics. An example of such an occurrence is the research conducted under the topic of “knowledge ecosystems”, though relatively smaller in number of records and low overlap with BE, IE and DE, may be significant in contribution to the field. Even for cases where the research field is developed to a larger extent, the dataset can be expected to be just a snapshot of that period. Source data may therefore contain some noise for the purposes of ecosystem categorization or miss relevant papers, resulting in some less precise boundary topics characterization. This data source quality aspect has limited the authors from conducting a more comprehensive breadth and depth analysis with more examples of clear domain co-occurrences between ecosystem types beyond “smart city”, “digital business ecosystem” and “helix”. The tripartite framework suggested is also likely to be dynamic due to the emerging nature of ecosystem literature. Depending on the time period analyzed, some domains may merge or spin-off, thereby potentially modifying the high level definitions suggested. In spite of this limitation, our method has been able to programmatically provide evidence of less obvious knowledge sharing for a range of keyword type examples representing a general keyword (Smart City), overlapping keywords (Digital Business Ecosystem) and domain exclusive keyword (Helix).

The second limitation is the possible lower comprehensiveness of the keywords and networks identification. As an example, the filtering method eliminated most common single words or unigrams though generic keywords and unigrams may offer desirable clues when studying newly emerging domains. Some newly emerging fields with lesser related keywords and relying more on unigrams, therefore, may appear insignificant. An emerging concept might also be proposed by integrating certain multi-grams representing existing generic concepts,

non-domain type keywords, highly connected keywords and least connected keywords, which were also pruned by our selected thresholds. As an example to support this limitation is the domain of “digital health”, which was connected to 4 keywords in this analysis while it would be connected to 24 keywords without the noise filtering method. One of the filtered out new domains found for this example was “ambient intelligence” that clearly supports digital health initiatives. A key objective of this study was to analyze the ecosystem types at a high level to assist in further defining them and their boundaries using literature derived themes. While we believe this objective is achieved, when a more targeted search for related domains to a specific one of interest is desired, our method can be modified to overcome the limitation by using different pruning levels and even re-inclusion of eliminated keywords appearing without noise filtering.

The third limitation is the lack of visibility into foundation domains and theories. Our analysis investigates inherent and overlapping keywords within IE, BE, and DE. Their background and theory may have origins in disciplines like ecology, management science, policy science, and engineering, which are outside the scope of our analysis. The clues generated however may suggest knowledge sourcing domains and may lead to relevant second order nodes or domains. More mature domains may need to be analyzed separately in varying time periods. Similar search for more fundamental or highly cross functional domains may result in useful insights using this method.

The dataset used in this study is therefore partial and not ideal for assessment of cross domain knowledge sharing for newly emerging fields. Further research on specific emerging domains that includes the larger data set may be more valuable to identify non-generic associations with more matured disciplines and fields.

The theoretical contributions of this study are centered on improved definitions of related emerging domains and knowledge cross-sharing amongst them. Previous theoretical studies have at times used BE, IE and DE in an interchangeable manner. For instance, DE may appear to be a subset of BE and IE, such as a context or technological solution, which we have analyzed using keyword network analysis. Our theoretical contribution is the reorganization of existing ecosystem related concepts based on cross-domain keyword analysis. We discussed and identified unique features of BE, IE, and DE and their focus areas in science, technology, policy (IE), actor, network, strategy (BE) and digital technology (DE). We also analyzed knowledge cross sharing and characterized their key topics i.e. open innovation and societal development between IE and BE in physical system, information and service systems between BE and DE in cyber system and virtual and social systems between DE and IE in cyber-physical system.

We also identified common and core issues of the ecosystems as knowledge and orchestration of ecosystems. These distinctions within the integrated framework, as demonstrated in the paper, offer comprehensive and diverse perspectives on complex concepts like smart city and triple helix.

The deeper understanding of the general landscape, co-existing and cross sharing domains could aid in growing the bodies of knowledge discretely and collectively. The collective growth aspects are a unique contribution in this study. The potential relevance to industry is similar in terms of guidance on engaging less obvious domains for facilitating innovation diffusion. A research scholar or business professional seeking to learn about a specific ecosystem can be aided with a checklist of related domains for a more comprehensive coverage.

The keywords in literature associated with BE, IE and DE and their weightage could change in later stages of consensus on ecosystem domains definitions. This could impact the classification and themes suggested in this study. We have observed this possibility in few domains overlapping records. Our data filtering method for noise reduction eliminated common unigrams that are highly connected across the literature. This approach could eliminate analysis of emerging domains that rely more on unigrams. Our pruning method has eliminated keywords containing certain generic multi-grams, thereby reducing their network size and therefore the significance of topics that are linked to such keywords. Our method of revealing topics may also not be comprehensive enough to detect contributing foundation domains and theories.

Applying similar methods in a future time period for the three ecosystems and comparing with the findings in this study could offer insights into the dynamic state of related knowledge bodies and identify some as maturing, converging or spinning-off into specific trajectories. This type of information could be valuable to financial investors, entrepreneurs, large corporations, SMEs, academicians and policy makers for more informed decision making on investing or influencing innovation directions.

Further studies on importance of keywords more frequently occurring in titles of articles alone (that may get higher readership) versus in both titles and abstracts as used in this study could fine tune keyword weightage levels to validate characterizations. In the same lines, weightages considerations from results of full text keywords analysis can be compared with results of this study for potential topics characterization quality enhancement. Alternate keywords network splits and filtering methods can be applied to identify targeted domain related knowledge cross-sharing opportunities.

## **2.6 SUMMARY**

Current state of knowledge contained in the domains of Business Ecosystems (BE), Innovation Ecosystems (IE) and Digital Ecosystems (DE) have been differentiated using keywords added by authors as well as extracted from titles and abstracts (jointly termed as Master Keywords). The use of such master keywords is an enhancement in quality over solely the use of author biased keywords to identify related bodies of knowledge. The identified ecosystem domains are represented in a tripartite framework to depict the current state of literature classification. This overall finding offers an evidence based approach to support prevailing definitions of the ecosystems and pioneering in defining their overlapping boundaries. This study has additionally conducted keywords network analysis to identify the less obvious ecosystem domains that collaborate or source knowledge from each other. The keywords filtering method used has highlighted cross knowledge sharing occurring between the ecosystems for the relatively larger domains of Smart Cities, Digital Business Ecosystem and Helix.

### **3. CASE STUDY OF ELECTRIC VEHICLES ECOSYSTEMS**

#### **3.1 INTRODUCTION**

In the formation stages of a business ecosystem, firms fulfilling a major business function that benefit from network effects may initiate new capability development and collaboration through deals such as mergers, acquisitions, joint ventures and other contractually binding agreements [79]. Such ‘formation hub firms’ may not be customer facing or owning the customer experience as the eventual platform leader<sup>2</sup>. An example of such a hub firm is an infrastructure builder who supplies a critical infrastructure need and also integrates various components supplied by other firms to enable platform functions. The initiatives around establishing the 5G network [80], for instance, promise to enable an ever growing number of use cases for new business ecosystems, many of which may compete with each other [81].

Towards the objective of gathering insights on ‘formation hub firms’, we analyze deals activity of firms related to the global electric vehicles (EV) industry. We conduct a literature review of related domains that include theoretical and empirical studies, as well as studies that used deals analysis. We apply network analysis on the EV related deals to identify the ‘formation hub firms’ and conduct their detailed profiling. Finally, we isolate distinct factors for emerging ecosystem formation and propose a strategies typology of hub firms based on their inclinations of positioning within their respective ecosystem to provide actionable guidance for innovation strategy.

#### **3.2 LITERATURE REVIEW**

Due to various sets of motivations in varying degrees of importance, the transition of automotive industry to electric drive is occurring at a faster pace in certain specific global regions. While the EV adoption case is not a new one [82], its latest cycle of renewed interest in terms of significant investments started in the year 2000 with Toyota Prius worldwide release [82]. Major investment by China and the Republic of Korea since 2009 is more recent [83] [84]. Each of the regions with faster pace of adoption is engaged in interactions between academia or research, industry sector, government bodies, society and civil participants or media-based and culture-based public and natural environments of society (specifically global

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<sup>2</sup> A platform leader or focal firm delivers a streamlined product or service to the end user customer through collaborations and governance of its network partners [28].

warming), making it a case study of the “Quintuple Helix” model of innovation [74]. While customer dominant logic [85] in terms of greater convenience at a much lower cost of utilization for EV passengers holds justifiable merit as a business model, the readiness of associated physical components and infrastructure must exist at a threshold level to enable it. From an ecosystemic view, the reaction of the deeply entrenched businesses like conventional petrol and diesel automobiles manufacturing, oil industry, car dealers and others that may stand to lose substantially must be factored in. We analyze the various interactions from a business ecosystem perspective.

A business ecosystem framework for analyzing innovation diffusion goes beyond the product supply chain and economics based considerations to include influence of externalities from complementaries<sup>3</sup>, intermediaries and influencers [28] [87]. Ecosystem actors in any position with respect to a focal firm who navigate jointly through all possible co-innovation and co-adoption risks are positioned for a higher likelihood of innovation success [32] [26]. It is suggested that both these risk types can be alleviated through effective collaborations and R&D investments over time. Factors that influence firms to engage in emerging business ecosystems have also been studied in context of innovation diffusion, dominant design, industry (external) platforms, keystones, ecosystem health and performance indicators, ecosystem reliability and system transition among others.

The notion of appealing to early adopters who seek opinion leadership through acquiring a novelty at a premium price [88] is visible in buyers of Tesla EVs whose pricing has been substantially higher than equivalent Internal Combustion Engine (ICE) sedans [89]. However, a causal explanation for this due to ecosystemic forces especially at more localized areas cannot be ignored. Early literature on dominant design, i.e. a design that is widely adopted and changes the nature of competition, has clearly demarcated product and process innovation by suggesting that the adoption rate of the former is substantially higher in the beginning stages [90]. This approach also helped establish that technological forces could not be predicted simply from demand characteristics [91]. This view is further propagated by a recent futuristic forecast by Stanford University economist Seba, who details the trends of next generation cars transforming into “computers on wheels” as the basis for suggesting that the pace of mass adoption of EVs as self-driven and pooled on demand will be driven by technology rather than climate politics [92].

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<sup>3</sup> When the product’s value to customers is more with a complementing product or service [86], for example, Intel and Microsoft (Pentium processors and Windows), or Microsoft and McAfee (Microsoft Windows & McAfee anti-virus).

More recent literature on dominant design, advocate considering products as complex artifacts that evolve as a nested hierarchy of technology cycles with multiple mechanisms that contribute towards evolution of the dominant design [93]. One mechanism for complex products suggests emergence of dominant designs due to a combination sociological, political and organizational dynamics. China's mass scale action in establishing a globally leading EV production and associated charging infrastructure [94] is likely influenced by high societal (health) cost from automotive pollution levels but also has an economic basis to reduce reliance on ICE vehicles and related imports while at the same time leveraging high domestic reserves of lithium mineral essential for Lithium-ion (Li-ion) batteries for EVs. Another mechanism suggests a self-reinforcing process such as collaborations by firms leading in early market share.

Literature on ecosystem health has identified robustness, productivity and niche creation as measures of health [95]. Achievement of robustness for survival against a variety of disruptions is suggested through the presence of a stable hub that promotes loosely connected network of agents to build novel capabilities. The stable hub actors, also labeled as keystones, provide a platform for its members and regulate the health of the total ecosystem. As membership in the ecosystem grows, its bargaining power and ability to pull new members increases, thereby increasing the overall value creation [96]. The ecosystem should be productive as well in converting raw materials of innovation efficiently and continuously to reduce costs and deliver value in terms of new technologies, processes and ideas to its members. The productivity in delivering new technologies should result in niche creation such as new businesses and products.

In the early stages of an emerging ecosystem, while pockets of niche creation, dominators and supporting infrastructure can be observed, keystone players that legitimize the ecosystem value offering a platform are often yet to appear. System transition literature suggests pathways for ecosystem growth influenced by landscape developments and socio-technical regime that impact the timing and rate of growth [97]. For the case of the global EV industry, niche creation for Li-ion battery technology and its mass manufacturing, electromechanical systems, self-driving enabling technologies and others are visible. From an industry platform perspective, multi-sided market creation [22] is observed in car-pooling services such as Uber that are currently agnostic to vehicle drivetrain technology (ICE or EV) but transferrable to a future self-driving regime.

Industry re-alignment that promotes ecosystem evolution and growth is often accompanied with high intensity of firm level deals activities such as mergers, acquisitions, strategic

alliances, joint ventures, capital injections and other financial transactions. Literature on Mergers and Acquisitions (M&A) for the objective of advancing an innovative capability has been widely studied in context of integration and post deal performance [98] [99] [100] [101]. Network analysis of ecosystems has been applied to derive insights from investment firms financing innovation ecosystems in China [102]. Deals analysis triangulated with executives and funding relationships, public opinion and discourse have been applied for quantifying the complex relationships between sets of two representative firms existing within their own ecosystems each for acquisition, coopetition and strategic alliance [103]. This study applies deals network analysis to identify hub firms for the objective of deriving insights on ecosystem formation strategies.

We make a distinction between ‘formation’ hub firms central to the clusters revealed by the deals network analysis, and the eventual ‘operational’ hub firms or keystone or focal firms. The formation hub firms contribute to niche and infrastructure building essential for the formation of an ecosystem. We isolate these formation hub firms based on their deals activity and profile them using publicly available rationale of deals, press releases and news reports.

### **3.3 DATA AND METHODS**

Data from Zephyr Database of Bureau van Dijk Electronic Publishing (BvDEP) describing global M&A, IPO, and Private Equity deals is utilized. The database includes over 1.1 million completed, announced and rumored deals. Data sources are from Advisor Submissions, Company Press Releases, various electronic publications of business news, Stock Exchanges and Company Websites. A comparison with the other leading M&A database, Securities Data Company M&A (SDC) by Thomson Reuters has suggested that Zephyr offers better information on precise questions, while SDC is better suited for general research [104]. Zephyr M&A data has been used in a variety of publications that include post merge financial trends, performance and social impact [105] [106] [107], analysis of public-private vs private-private deals [108], legal origin of M&A deals [109], rationale of deals categorization for innovative advances [110] [111] [112] and M&A trends by industry sector [113].

Using the search equation as “electric vehicle\*” OR “electric car\*”, we found 2,144 deals between acquirers and targets on the date of retrieval on April 25<sup>th</sup> 2018. Information such as deal status, type and rationale is also offered by the database. Data preparation and processing steps are listed below.

- Deal Status: Ranged from variations of announced, completed, assumed completed, pending, rumor and withdrawn; only completed or assumed completed deals are used for analysis in this study and hereafter referred to as “deals”.
- Deal Type: Ranged from variations of acquisition, IPO, minority share increase, institutional buy-out, management buy-out, capital increase, share buy-back and joint venture; all types were utilized as a indicator of activity level.
- Acquirer Name: Several fields were blank for deals that were not between 2 parties e.g. IPOs, capital increase and minority stake increase; the “target name” was used for such blank entries
- Generic Company name duplication: Both “acquirer” and “target” company names included certain investor types with exactly the same name e.g. investor, investors, private investors, etc. (total of 36 types) that are repeated and can wrongly appear to be a unique entity in the network; uniqueness by an additional numeric identifier to the company name was the method used to eliminate this duplication

This information is used to create a network of deals where the acquirers and targets act as nodes and a link joins those that have undertaken deals. Each deal transaction has a direction of the investment, but in this study is neglected as we focus on the number of transactions a company has been involved with. The result is a network of deals that can be decomposed into clusters, referring to groups of companies tightly connected by the financial transactions that occurred among them. The Louvain algorithm [58] was applied for this purpose revealing prominent clusters and their respective hub firms. Deals data represented in this manner help to identify the most active deal-making firms associated with the global EV industry. Hub firms of the clusters exhibit higher connectivity in the network; the number of connections is defined as “degree”. Firms with the highest degrees of connectivity, and clusters of firms with a high degree of interconnectedness are shortlisted for deeper profiling. For a visual perspective, these shortlisted hub firms are plotted by their head office or primary manufacturing geographical location and time scale of activities. Deals of the selected hub firms are further analyzed for rationale from company press releases for relevance to EV related investments (more applicable for conglomerates with major non-EV business units).

Finally, using corporate web sites and company press releases included in the Zephyr database rationale of deals and supplemented by news sources, the hub firms activities are analyzed for their EV industry related strategies to assess their preferred level of presence in

the industry. The resulting findings offer insights on approaches adopted by firms seeking to benefit from the formation of the global EV ecosystems.

### 3.4 RESULTS

#### 3.4.1 Clusters of Deals Activity

The data set comprises deals ranging from 1997 to the date of retrieval in 2018. There were 2,144 deals of which 1,475 (68.8%) were completed or assumed completed. These include transactions among 1,954 companies from a variety of industry sectors. The number of deals steadily increased over the years as shown in Figure 3-1.

The transactions varied in their nature. Table 3-1 shows the types of deals found. Deals related to minority stake purchase were the most in number. The deals network of 1,954 companies comprised mostly of in-house deals or between two companies, thereby resulting overall in a highly disconnected network. As illustrated in Figure 3-2, the network additionally contained 623 mostly isolated clusters with 70% of the clusters being single deals between two companies. Only 21 (4%) clusters contained more than 10 companies within them. A few companies stand out on higher connectivity implying that their transactions occurred amongst multiple companies or stakeholders.

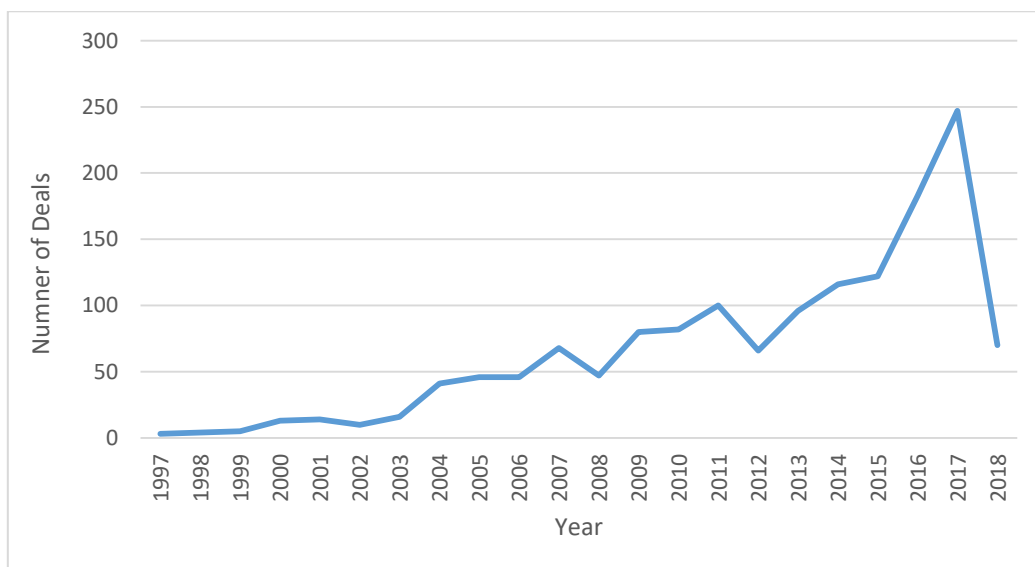


Figure 3-1 Electric Vehicles related deals trends

Similarly, a few companies stand out from a degree distribution perspective which offer an indicator of tightly knit nodes with a relatively high density of ties [114]. Table 3-2 summarizes the characteristics of the clusters having 8 or more connected companies. Besides the numerical Cluster ID, we identify each cluster by the name of its primary hub company. The clusters in the table are sorted in descending order of number of companies participating. Cluster 1 that includes 70 companies is the largest one. Table 2 also offers a historical view in terms of the average year of the deals associated with hub companies of the clusters. On average, the oldest transactions occurred for clusters 18 (ZAP) and 4 (Haldex). In contrast, clusters 22 (Hangzhou), 9 (China Environmental Energy Investment), and 24 (CH-Auto Technology Corporation) had the most recent deal activities. The more recent interest for adoption of EV technologies in China are supported by the transaction periods of these three China-based companies.

Table 3-1 Types of transactions involved

<b>Type of transaction</b>	<b>Deals</b>
Minority stake	476
Acquisition	392
Capital Increase	238
Joint venture	152
Acquisition increased	104
Initial public offering	26
Institutional buy-out	15
Management buy-out	5
Planned IPO	4
Acquisition remaining	3
Share buyback	1

Table 3-2 Characteristics of Hub Firms of the largest EV linked clusters of the deals network

Cluster ID	Firms in cluster	Deals made	Average year	Hubs	Hub's Country	SIC Classification	Degree
1	70	71	2007.0	JOHNSON CONTROLS INC.	USA	Storage batteries	58
				AZURE DYNAMICS CORPORATION	Canada	Motor vehicle parts and accessories	14
2	42	46	2009.6	TANFIELD GROUP PLC	UK	Offices of holding companies, not elsewhere classified	27
				SMITH ELECTRIC VEHICLES US CORPORATION	USA	Motor vehicles and passenger car bodies	9
3	29	30	2011.3	BYD CO., LTD	China	Storage batteries	29
4	29	29	2006.5	HALDEX AB	Sweden	Motor vehicle parts and accessories	30
5	25	25	2013.2	JIANGSU ZHONGTIAN TECHNOLOGY CO., LTD	China	Drawing and insulating of nonferrous wire	25
6	25	26	2007.2	TECO ELECTRIC & MACHINERY CO., LTD	Taiwan	Motors and generators	23
7	24	25	2014.6	AVIC ELECTROMECHANICAL SYSTEMS CO., LTD	China	Aircraft parts and auxiliary equipment, not elsewhere specified	19
8	23	24	2010.9	TESLA MOTORS INC.	USA	Motor vehicles and passenger car bodies	20
9	19	19	2015.2	CHINA ENVIRONMENTAL ENERGY INVESTMENT LTD <sup>4</sup>	Bermuda	Refuse systems	18
10	15	19	2010.4	SK ENERGY CO., LTD	Republic of Korea	Petroleum refining	9
				KOREA ELECTRIC TERMINAL CO., LTD	Republic of Korea	Electronic connectors	9
11	15	15	2012.7	CHARGEMASTER PLC	UK	Electrical industrial apparatus, not elsewhere specified	7

<sup>4</sup> China Environmental Energy Investment Ltd. is not included in the company profiling as it is purely an investment firm.

Cluster ID	Firms in cluster	Deals made	Average year	Hubs	Hub's Country	SIC Classification	Degree
12	13	14	2010.4	CHARGEPOINT INC.	USA	Gasoline service stations	6
13	12	12	2011.2	METROELECTRIC PLC	UK	Automobiles and Other Motor Vehicles wholesale dealing in	13
14	11	10	2013.6	NINEBOT (TIANJIN) TECHNOLOGY CO., LTD	China	Electrical industrial apparatus, not elsewhere specified	5
15	11	10	2008.8	HEULIEZ SA	France	Motor vehicles and passenger car bodies	7
16	11	10	2012.0	VALMET AUTOMOTIVE OY	Finland	Motor vehicles and passenger car bodies	10
17	11	10	2010.8	PHILLIPS & TEMRO INDUSTRIES INC.	USA	Motor vehicle parts and accessories	10
18	10	9	2006.3	ZAP	USA	Motorcycles, bicycles and parts	9
19	10	9	2009.8	POLARIS INDUSTRIES INC.	USA	Transportation equipment, not elsewhere specified	4
20	10	10	2009.4	ECOTALITY INC.	USA	Electrical industrial apparatus, not elsewhere specified	10
21	10	10	2010.0	GND WINTECH CO., LTD	Republic of Korea	Industrial instruments for measurement, display and control of process variables and related products	11
22	9	9	2015.1	HANGZHOU ZHONGHENG ELECTRIC CO., LTD	China	Computer programming services	10
23	9	9	2016.6	CH-AUTO TECHNOLOGY CORPORATION LTD	China	Motors and generators	10
24	8	8	2007.6	CHINA MOTOR CORPORATION LTD	Taiwan	Motor vehicles and passenger car bodies	9

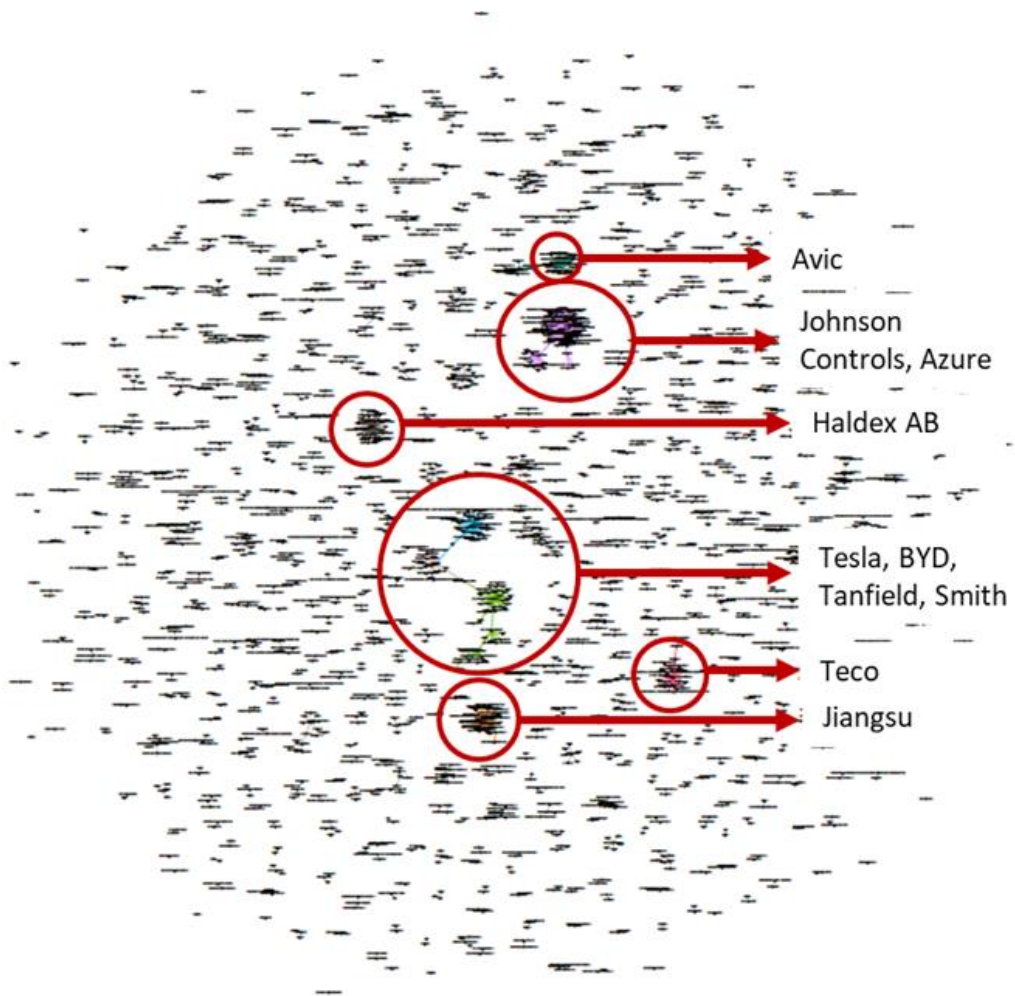


Figure 3-2 Deals network of Electric Vehicles (1,954 companies in 623 clusters)  
(largest clusters are circled)

### 3.4.2. Formation Hub Firms Profiling

For deriving the ecosystems formation insights, we focus on those highly connected hub companies that are outliers, which are defined herein as having a degree of 10 or higher. Based on this criteria, clusters 1, 2, 3, 4, 5, 6, 7, 8, 13, 16, 17, 20, 21, 22 and 23 are profiled in detail in later sub-sections. The largest connected hub firms among them and their primary business functions and geographical locations on a time scale are illustrated in Figure 3-3. The high deals intensities of the hub firms based in US, Sweden, UK, Finland and Taiwan occurred in the year 2003-2008. For hub firms based in China, deals activities peak period was 2008-2013 and in the Republic of Korea in the years 2013-17. Various factors such as firm strategy,

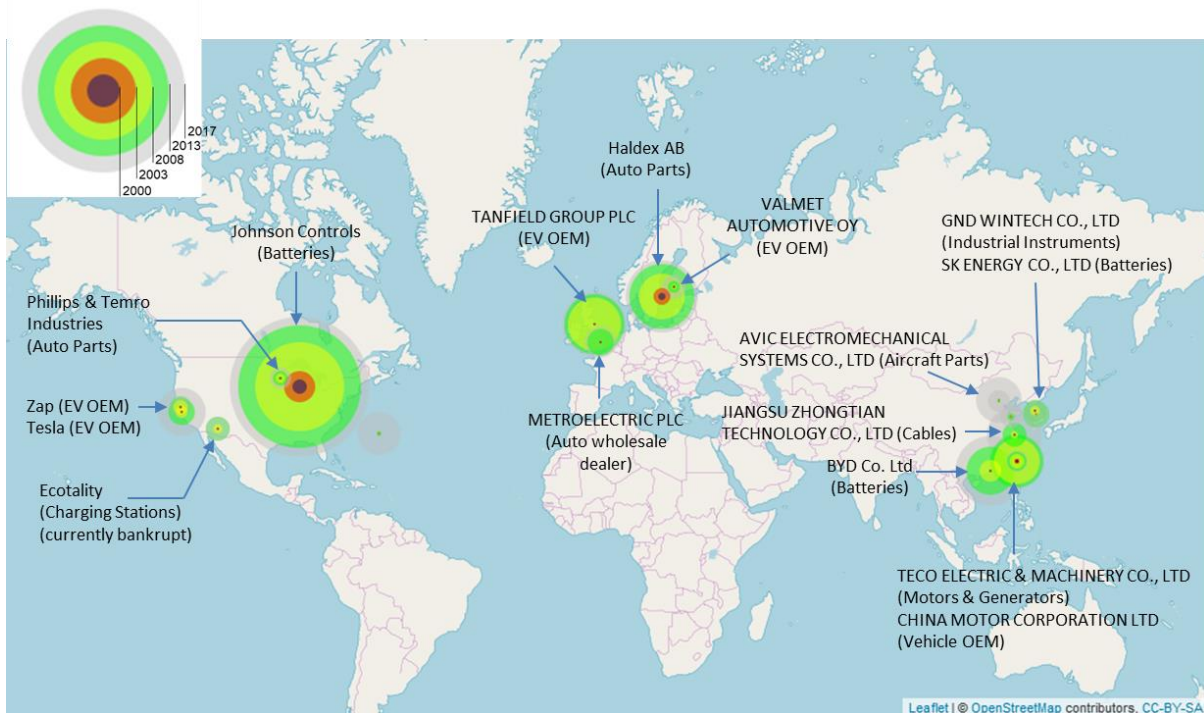


Figure 3-3 Electric Vehicles related Deals Activity Clusters by Hub Firm and period (for greater than 8 degrees of network size)

leadership and country policies may offer explanations for this observed trend. Business functions and EV related strategies of each of these hub firms are further analyzed till date of retrieval of deals data or more recent news covering related historical information. Some clusters are weakly linked to others which are discussed on Section 5.1. In the rest of the article, each cluster is named after its hub.

### 3.4.2.1 Cluster 1 Hub - Johnson Controls International plc, Ireland, USA; Azure Dynamics Corporation, USA

Johnson Controls International plc (JCI) is a conglomerate originated in USA and currently headquartered in Ireland. JCI's automotive battery division is globally the largest lead acid battery manufacturer with US\$7.3 Billion and production of 154 million batteries per annum. However, JCI global market share of EV specific Li-ion batteries is less than 5% [115]. With JCI and its subsidiaries as acquirer, out of 61 deals, 14 were related to automotive batteries with 2 within them related to Li-ion batteries, 21 related to automotive interiors, 2 minority capital increases were for Azure Dynamics Corporation (Azure) that manufactures EV related components and others unrelated to automotive products. With JCI and its subsidiaries as target

firm, out of 25 deals, 3 were related to automotive batteries with 2 within them related to EV batteries, 5 related to automotive parts and interiors, 7 related to financial transactions between shareholders and investors and others unrelated to automotive products. One of the EV related deals in 2013 was Saft Groupe SA acquiring a Li-ion battery plant based in Nersac, France from Johnson Controls Inc. JCI's press release in March 2018 suggested a possibility of spinning-off their automotive battery division with US\$7.3 Billion turnover in 2017 for a more streamlined operations focus on their other divisions [116]. While EV batteries capability and capacity of JCI becomes available to others, the case for JCI as a future major EV hub firm currently is not well supported.

Azure Dynamics Corporation (Azure), originally incorporated in Canada later moved operations to USA, was engaged in development and supply of electric and hybrid electric power trains and vehicle control systems for light and heavy duty commercial vehicles in North America [117]. Due to financial difficulties, Azure filed for bankruptcy protection in March 2012 [118]. As an acquirer, Azure had 2 deals – one was 100% acquisition of Solectria Corporation, a hybrid electric, fuel cells, and distribution power generators manufacturer based in USA, and second was a joint venture with Smiths Electric Vehicles (Smith) to develop hybrid electric powertrains for commercial and military vehicles. As a target, Azure had 21 deals primarily from investors and financial instruments for raising funds. More notably, 2 of the minority stake addition deals were with Johnson Controls (JCI) linking it to the EV ecosystem of battery production of both lead acid and Li-ion that was a core offering of JCI for the EV industry.

#### 3.4.2.2 Cluster 2 Hub - Tanfield Group plc, UK; Smith Electric Vehicles Corp., UK

Tanfield Group Plc (Tanfield) operates as an investment company with 49% interest in Snorkel International Holdings which produces self-propelled, towable, and push-around aerial lifts. In 2004, Tanfield acquired 5.76% interest in UK based Smith Electric Vehicles Corp. (Smith) which designs and produces electric commercial vehicles for short haul urban fleets. In 2011, Smith planned an IPO at NASDAQ which was later withdrawn. In 2015, Smith in an effort to expand its EV business into the US market entered into a joint venture with FDG Electric Vehicles Ltd. [119]. This joint venture however got embroiled in a lawsuit impairing its ability to raise funds to grow [120]. Tanfield's presence in EV industry is through Smith. Tanfield and its subsidiaries' deals as target were 37, which included acquisition of Smith (by Tanfield's Smith Electric Vehicle Division) and remaining were minority stake related

financial transactions between shareholders and investors with no stated emphasis on EV. Tanfield as acquirer had 6 deals, including acquisition of Smith. Other deals included acquisitions unrelated to EV products and financial instruments to fund the acquisitions. Smith as acquirer had two deals, one was related to Tanfield acquisition and other to acquisition of a financial advisory firm. Smith had four completed deals as target related to financial transactions between shareholders and investors. One of the deals of Smith that may have relevance to EV products was a letter of intent (LOI) with Wanxiang Group Corporation, a China-based multinational automotive parts manufacturing firm for USD 25 million investment as a private placement.

#### 3.4.2.3 Cluster 3 Hub - BYD Co. Ltd., China

BYD Co., Ltd. (BYD) is a China-based automobile manufacturer whose principal activity is the design, development, manufacture and distribution of automobiles, buses, electric bicycles, forklifts, rechargeable batteries and trucks. BYD's 50:50 joint venture with Daimler AG, Shenzhen BYD Daimler New Technology Co., Ltd. develops and manufactures luxury electric cars sold under the Denza brand. BYD's revenues grew steadily from 41.11 billion yuan in 2009 to 105.91 billion yuan in 2017 [121]. BYD is listed on the Hong Kong and Shenzhen Stock Exchanges, with revenue and market capitalization each exceeding RMB 100 billion. Out of BYD's 6 deals as acquirer, 3 were related to upstream integration for Li-ion battery manufacturing as described below.

- Joint venture with Qinghai Salt Lake Industry Co., Ltd and Shenzhen Zhuoyucheng Investment Co., Ltd. for China based lithium products and resources manufacture.
- Minority stake in Tibet Mineral Development Co. Ltd. which focuses on mining for lithium mineral, thereby securing source material for its Li-ion battery manufacturing.
- 100% acquisition of SinoMOS Semiconductor (Ningbo) Inc., a wafer manufacturer in China, for further upstream integration for EV manufacture.

BYD's remaining 3 deals as acquirer were related to building vehicle manufacturing capability, namely major stake in state-owned compact-car maker Xian Zhen Chuan Automobile in two stages, and 100% acquisition of Hunan Midea Coach Manufacturing Co., Ltd. which is involved in the development, manufacture and sale of buses and coaches. Out of the 51 deals where BYD and its subsidiaries was the target, four were capital injections and

most notably by MidAmerican Energy, a unit of Warren Buffet's Berkshire Hathaway to invest USD 230 million in BYD for a 10 per cent stake in the Chinese company and others through private placement and IPO. The remaining 47 deals were additional smaller capital injections through largely financial transactions of minority stakes acquisitions and minority stakes increases by investment firms and private investors.

#### 3.4.2.4 Cluster 4 Hub - Haldex AB, Sweden

Haldex AB, a Sweden-based company with current turnover of approximately SEK 4.4 Billion, develops, manufactures and distributes products for brake and suspension systems for commercial vehicles. Haldex is a global leader in supply of automotive brake adjusters for drum brakes with the fastest growing market share for air disc brakes [122]. From its product portfolio, only electromechanical disc brakes or brake by wire apply to electric vehicles. Haldex deals activities included 10 deals as acquirer and 43 deals as target. Most of the deals were financial transactions between shareholders and investors. The remaining deals were mostly related to their strategic decision to split its 4 divisions in 2011 through spin-offs and divestments for core focus on brake and suspension systems for heavy vehicles. None of the deals were directly related to electromechanical disc brakes that link to the EV industry. Electromechanical disc brakes related development initiatives of Haldex have however been through participation in SWEP project (2004-2008) and the EU Projects SPARC (2004-2007) and HAVEit (2008-2011) [123]. In 2016, Haldex and Zhejiang VIE Science and Technology Co., Ltd. (VIE) entered into a joint venture to design, develop, produce, and sell electromechanical brake systems for commercial vehicles with an initial focus on the electric bus market in China [124]. Haldex has been a proponent of open vehicle system architecture to engage autonomous driving ecosystem partners representing the functions of steering systems, 'intelligence, sensors and communications', HMI telematics, powertrain and vehicle OEMs [123] [125].

#### 3.4.2.5 Cluster 5 Hub - Jiangsu Zhongtian Technology Co., Ltd. / ZTT International Ltd., China

Jiangsu Zhongtian Technology Co., Ltd. and Zhongtian Technology Group Co. Ltd. previously known as Jiangsu Zhongtian Silk Co. Ltd. [126] are part of ZTT International Ltd. (ZTT). ZTT reported 2018 turnover of about 33 billion yuan and primarily engages in the

manufacture and distribution of fiber optic communication and power transmission products worldwide. ZTT's product range is divided into (i) Energy Systems which includes high tension cables, transformers, large conductors, optical ground wires (OPGW) and other components including installations covering a total capability for EV power transmission infrastructure; (ii) Telecom Systems which include optical and RF cables, antennas and other components that are required for EV data transmission; (iii) New Energy that includes solar lithium battery and solar photovoltaic technology and components; and lastly (iv) Submarine systems and other marine cabling components that are not relevant to EV industry unless undersea power transmission is needed in certain regions across water bodies [127].

ZTT had 29 deals as acquirer that were primarily transactions between its shareholders, subsidiaries and investors. Among EV related deals, 2 were capital injection to its subsidiary Zhongtian Energy Storage Technology Co., Ltd., that manufactures lithium batteries. Among other deals that may be relevant to EVs and associated infrastructure, 6 deals were related to optical fibers, one for transformers, one for broadband technology, one for software, two for solar cells and three for electrical fittings and conductors. Three deals that are likely unrelated to EVs were related to undersea cables capability. The remaining deals were related to general cables manufacturing, aluminum cables, steel pipes, real estate and purely financial transactions between shareholders and investors. ZTT had 41 deals as target which were related to financial transactions for capital increase and minority stake between shareholders, subsidiaries and investors.

#### 3.4.2.6 Cluster 6 Hub - Teco Electric & Machinery Co., Ltd., Taiwan

Teco Electric & Machinery Co., Ltd. (TECO), a Taiwanese conglomerate with 2018 turnover of 51.7 TWD [128], manufactures a complete line of motors including heavy duty permanent magnet motors, AC induction motors, brake motors, inverters and DC generators that apply to EVs [129]. Other EV related capabilities of TECO include automation products comprising AC servo driving systems, programmable logic controller, human-machine interface and robots. TECO also offers EV battery chargers, integrated IOT / cloud based Smart Card applications wind turbines and solar PV power station products [130]. TECO had 17 deals as acquirer that include two related to motors, two related to telecommunications and digital applications, one related to wide industrial use power cables, one related to wind turbine parts, one related to EV battery chargers, financial transactions between its shareholders, subsidiaries

and investors and others unrelated to EV products. TECO had 12 deals as target related to financial transactions between its shareholders, subsidiaries and investors.

#### 3.4.2.7 Cluster 7 Hub - Avic Electromechanical Systems Co., Ltd., China

The hub firm AVIC Electromechanical Systems Co., Ltd. is a subsidiary of AVIC Group industry [131]. Aviation Industry Corporation of China, Ltd. or AVIC Group (AVIC) primarily provides diverse products and services for the aviation sector. For the EV industry, AVIC's business units offer electricity storage equipment, wind power equipment and electromechanical systems. Their portfolio of energy storage equipment includes super capacitors and lithium battery automatic production line. Super capacitors product line applications include fast charging to recycle energy, efficient starting of aircrafts, heavy vehicles, UAVs and defence vehicles, and automotive idling start-stop to conserve energy. AVIC as acquirer had four deals, which included acquisition of Hilite International Inc., a US automotive components and systems manufacturer; acquisition of Kriftel, Germany-based car seat moving components manufacturer; and minority stakes in its subsidiaries. As acquirer, AVIC had 6 deals that included funds injection by external investment firms and financial transactions between shareholders, subsidiaries and investors.

#### 3.4.2.8 Cluster 8 Hub - Tesla Motors Inc., USA

Tesla Motors Inc. (Tesla) designs, develops, manufactures and sells fully electric vehicles, energy generators and energy storage systems. The energy generation and storage segment includes their equipment operation and maintenance for residential and commercial customers, or sale of electricity generated by its solar energy systems to customers. Tesla's fully electric vehicles include models for mass market, sport utility vehicles and luxury segments [132]. The Company offers loans and leases for its vehicles in certain regions. For self-reliance and competitive costing of Li-ion batteries for automotive and energy products, Tesla manufactures them in-house at large scale at its Gigafactory 1 [133] where Panasonic is the sole supplier of the batteries [134]. Tesla has combined in-house offerings of electric cars, batteries, renewable energy generation and storage to control supply of a major portion of the total EV ecosystem. Tesla had only 3 deals as acquirer. One is acquisition of SolarCity Corporation, a US based comprehensive solar power system installation services company. Second is acquisition of Riviera Tool LLC, a US based stamping die systems designer and manufacturer. Third is

acquisition of Grohmann Engineering GmbH, Germany based engineering services provider. Tesla had 29 deals as target which included IPO, financial instruments for fund raising and both sale and buy transactions between investors and shareholders. Several of these deals started as attempts towards opportunistic funding. Tesla's automotive related investors and shareholders include Daimler AG, Toyota Motors Corporation and Panasonic Corporation.

#### 3.4.2.9 Cluster 13 Hub - Metroelectric plc, UK

Metroelectric plc, UK (Metroelectric), originally a supplier and distributor of electric vehicles, was later acquired by Welney plc., an investment firm. Metroelectric's only deal as acquirer was 100% acquisition of Powabyke Acquisition Ltd, a London-based electric powered bicycle company. Metroelectric had 20 deals from investment firms and financial instruments to raise funds. No deals related to Welney plc were found and press releases had no mention of EV industry.

#### 3.4.2.10 Cluster 16 Hub - Valmet Automotive Oy, Finland

Valmet Automotive Oy (Valmet) manufactures automobiles through its turnkey vehicle program and vehicle contract manufacturing. The Chinese battery market leader CATL is a shareholder, along with two Finish investment firms. Valmet's engineering focus has been on future mobility solutions through digitization and automation among other innovations. Valmet is a leading supplier for electric vehicle battery systems and electric drivetrains. Valmet had 4 deals as acquirer with 3 related to automotive parts and one with an automotive engineering services firm. As a target, Valmet and its Chinese subsidiary had 8 deals.

#### 3.4.2.11 Cluster 17 Hub - Phillips & Temro Industries Inc., USA

Phillips & Temro Industries, Inc. (PTI) engages in designing and manufacturing a diverse range of thermal solution components and systems for automotive, off-road / industrial, Oil & Gas, power generation and power sports segments. Within their automotive segment, a small part of their portfolio catered to battery heaters for EVs and hybrids to keep batteries warm and ready for use and battery heater wire harnesses [135]. PTIs deals were not related to EV products.

#### 3.4.2.12 Cluster 20 Hub - Ecotality Inc., USA

Ecotality, Inc. (Ecotality) was engaged in designing, manufacturing, testing, and commercializing electric vehicle (EV) charging and energy storage. They produced charging stations for passenger vehicle applications, residential and commercial chargers, DC Fast Chargers, as well as a turnkey network operating system for EV drivers, commercial businesses and utilities. The company also provided testing and engineering consulting services that comprise EV Micro-Climate process, a planning and consulting program for municipal planning organizations and utilities for physical charge infrastructure installations at residential, commercial, and public locations. In addition, Ecotality offered power solutions comprising solar and battery pack manufacturing and assembly, electric charging station assembly and repair and maintenance services; and operated Fuel Cell Store, an online marketplace for fuel cell-related products and technologies with online distribution sites in the United States, Japan, Russia, Italy, and Portugal [136] [137]. Ecotality was incorporated in 1999 after winning a \$99.8 million grant from the U.S. Department of Energy and filed for bankruptcy protection in 2013 [138]. Ecotality as acquirer had 5 deals that included 100% acquisitions and one joint venture with a China-based investor. Its 100% acquisitions were related to advanced transportation systems to support battery electric vehicles and hydrogen technologies, a fast battery charger manufacturer, an online retailer for the fuel cell industry and a thin sealed rechargeable lead batteries and high quality flat-panel multi-crystalline solar modules manufacturer. As a target, Ecotality had 7 deals for funds injection through IPO, equity investments, private placements, debentures and 1 deal on filing for bankruptcy for acquisition of its remaining assets by Blink Acquisition LLC.

#### 3.4.2.13 Cluster 21 Hub - GND Wintech Co., Ltd., Republic of Korea

GND Wintech Co., Ltd. (GND) primarily manufactures remote controllers for household appliances, such as TV, DVD, air-conditioner and set top box for satellite reception. GND entered the EV industry through the company's acquisition of TOP Research Development, a Korea-based developer and manufacturer of EVs [139]. GND as an acquirer had 3 deals. One was a minority stake in a pulp manufacturer. Second was 100% acquisition of TOP Research & Development Co. Ltd.. Third was 100% acquisition of Dinos Co., Ltd, a Korea-based optical plastic manufacturer. As a target, GND had 7 deals that were minority stake additions and capital increases.

#### 3.4.2.14 Cluster 22 Hub - Hangzhou Zhongheng Electric Co., Ltd., China

Hangzhou Zhongheng Electric Co. Ltd. engages in the research, development, production and distribution of high frequency switch power supply systems [140]. Among its product offerings is Electric Vehicle Charging Systems that include AC vertical charging pile, AC wall-mounted charging pile, DC split charging pile, DC portable charging pile and DC integrated charging pile [141]. The company as an acquirer had 8 deals. These deals were related to acquisitions, minority stake and joint ventures for capability building in LED, wireless telecommunications, software, power distribution and remote monitoring. The company had no deals as target.

#### 3.4.2.15 Cluster 23 Hub - CH Auto Technology Corporation Ltd., China

CH-Auto Technology Corporation Ltd. (CH-Auto) designs, develops, manufactures, and sells conventional vehicles, new energy vehicles, and military vehicles [142]. CH-Auto entered into a strategic framework agreement with Navinfo for joint business development and strategic deployment in autonomous driving and IoV (Internet of Vehicles) areas [143]. CH-Auto had 1 deal as acquirer where it increased stake in a China based industrial design services company. As a target, the company had 4 deals, with 3 being with investors and 1 was IPO.

### **3.5 DISCUSSION**

The distinct clusters of EV related firms found in this study are representations of competing business ecosystems being formed to align with an emerging socio-technological alternative to transportation. The basis and dynamics of their formation can be investigated by analyzing strategies of the hub firms, nature of links between ecosystems, their coverage of the EV value chain, and incentives provided by their origin or operations country.

#### *3.5.1 Typology of deal strategy of hub firms and ecosystem structure*

Our analysis revealed several types of deal inclinations in the global EV industry. One set of deals comprised of investment in financial stock, acquisitions to increase product market share, strategic alliances along existing supply chains and capital injection to strengthen current partnerships along supply chain. This set of deals have less influence in changing the existing

structure of the supply chain and ecosystem. The other set of deals were more strategic that impact the position of hub firms within the ecosystems as they signal the hub firms' inclination of increased participation in the elements of the total ecosystem. The ecosystem around a hub firm whose inclination is scope expansion, has a circular structure and independent from other ecosystems. The typology of structurally impacting strategic inclinations are summarized in Table 3-3. The inclinations were derived by comparing the firm's core business function with the target's business function. As an example, the inclination was tagged as upstream or downstream if the target represented a value chain function that was upstream or downstream. The inclinations of the EV hub firms were found to consist of EV component suppliers seeking to expand their EV component product portfolios, upstream and downstream integration initiatives, conventional ICE automotive parts suppliers attempting to hedge their risks from potential technological change and entry into the new EV market. Some hub firms committed fully to the potential disruption, while others chose incremental innovation at varying degrees of readiness to scale from predominantly non-EV related products supply.

An added motivation for disruptive EV actors is the rapidly maturing Transport-as-a-Service (TAAS) model [92], coupled with on-demand autonomous vehicles. TAAS, in the form of carpooling technologies for Uber type services, is increasing the likelihood that individual car ownership will reduce in the medium term. This trend may be accelerated by on-demand rental vehicles and in the future, autonomous – vehicles offered by fleets, for which several such initiatives are in field testing stage [144].

Literature on firm level competitive strategy such as by Porter's Five Forces suggests focus on "threat of new entrants" and "threat of substitute products or services" [145], which is an understandable motivation at ecosystem level demonstrated by JCI and CH-Auto. Contracts and joint ventures as barriers to entry [146] [147] support ecosystemic competitive strategy as shown in the EV hub firms cases of components portfolio expansion and upstream or downstream integration.

While evidence supports supply chain integration initiatives as an aspect of ecosystem formation dynamics, the precise choices made by the hub firms could be a reflection of readiness of their target markets, unique resources available and governmental incentives (if any). As an example, sustainable sourcing of lithium mineral for production of Li-ion batteries is a significant consideration for scaling of the EV industry. China is the 3rd largest lithium

Table 3-3 Typology of strategic inclinations of hub firms deals

Deal Strategic Inclination	Examples	Innovator Type*
Components portfolio expansion	Jiangsu Zhongtian/ZTT (power transmission > Li-ion batteries, PV)	Incremental
	Azure (power train > hybrid electric, fuel cells)	Disruptive
	TECO (motor > cables, telecommunications, wind turbine parts, battery chargers)	Incremental
	AVIC (components for aviation, energy storage > car components)	Incremental
	Hangzhou Zhongheng Electric (power supply systems > other components)	Incremental
	Valmet (EV power train > parts and engineering services)	Incremental
Upstream integration	BYD (automobile manufacturer) > lithium mining, Li-ion batteries, semiconductors)	Disruptive
	Tesla (EV > PV)	Disruptive
	Ecotality (EV charging and energy storage > battery, PV)	Disruptive
Downstream integration	Haldex (electromechanical disc brakes > electric bus)	Incremental
	Metroelectric (EV components > electric powered bicycle)	Incremental
	GND Wintech (remote controller > EV)	Incremental
Technological threats motivated diversification	Johnson Controls (lead acid battery > Li-ion batteries)	Incremental
	CH-Auto Technology (EV > autonomous driving)	Incremental
New Market Entry	Tanfield (aerial lift > EV)	Incremental

\*Innovator type assessment as disruptive is based on the firm's intent and investment exclusively for EVs in a time of uncertainty on their mass adoption, while incremental is closer to hedging the risk with continued non-EV related traditional businesses.

producer globally in 2014 after Australia and Chile [146], giving it a significant edge in a future scenario of mass adoption of EVs. BYD has capitalized on this through minority stake in Tibet Mineral Development Co. Ltd. which focuses on lithium mineral mining. In contrast, India, a country battling severe automotive pollution levels in its cities, is scrambling to secure lithium reserves outside its borders much like its reliance on imported oil [147].

### 3.5.2 Country Influence

On analyzing the policies and incentives of the country of origin or operation of the hub firms, we have identified aspects of their influence. For China, EV as a primary future transport means offers substantial leverage as a country due to reduced dependence on importation of ICE vehicles, which also addresses the social need of reducing automotive pollution. This is supported by its heavy subsidizing policy for sales of all-electric vehicles [148] [149]. In

addition, China has established giant solar farms collectively accounting for the world's largest solar power capacity of about 130 GW [150][151]. It is, therefore, not surprising to see a significant presence of China-based hub firms. Motivation for the presence of hub firms from the Republic of Korea can be explained by the government's phased acceleration approach starting with major public sector procurement of EVs and associated infrastructure before extending to the private sector [84]. Another contrasting country case is of Sweden, where EV policies and legislation were defined early and encouraged "green cars" [152]. Due to their relatively smaller domestic market, Sweden-based and Finland-based firms often adopt an internationalization or born global strategy [153], which pushes technological development by design that is easily adaptable to faster and larger global markets. USA EV related firms receive relatively lower governmental incentives. Their presence as hubs can be attributed to a relatively high concentration of advanced technology IP, expert human resources and efficient funding for start-ups. Country incentives or disincentives can therefore be rationalized for their influence on promoting hub led emerging industries.

Country choice was a primary criterion for the highly promising diversified EV OEM firm Better Place, where infrastructure and geopolitics played a key role in their choice. Better Place offered a platform, battery power as a service, network of charging stations and partnership with Renault-Nissan attempting the world's first Electric Recharge Grid Operator (ERGO) model [154]. They selected the region of Israel as a likely early adopter region. Better Place was not successful and filed for bankruptcy in May 2013. None of the reasons attributed for this failure were believed to be directly related to the strengths of the ecosystem model [155], which therefore may re-emerge in future ecosystems.

### *3.5.3 Value Chain Coverage and Links between Ecosystems*

The EV value chain is broadly comprised of suppliers (components, sub-components or raw materials), EV OEMs (or vehicle manufacturers), intermediaries (such as automotive dealers), complementors (such as EV charging infrastructure providers) and services to end users (drivers or vehicle owners). The hub firms identified represent differing core capabilities required for the EV value chain (Table 3-4). These findings offer evidence that ecosystems formation can be led or facilitated by various value chain members. The notion that formation hub status can be achieved from any value chain position suggests that firm culture, health, aspirations, leadership and other firm specific factors, play a role in favorably in their

assessment of the risk-reward equation of investing in an emerging ecosystem. While network effects can be expected to benefit all ecosystem members, it is possible that some gain more than others. For the actors of the EV industry, the highest gainers can vary on a case by case basis due to relative margins they can earn in their respective markets, cost of sourcing components and raw materials (supply-demand balance), government incentives and disincentives, etc. Based on this reasoning, it is possible that a specific hub firm forecasts gains higher than a base threshold for investment. This aspect of which ecosystem actor stands to potentially gain high enough in a specific scenario to justify investment as a formation hub firm is an opportunity for further research.

Some of these early stage hub firms have chosen their presence in multiple business functions and assumed a dominant position in their respective cluster, while some hub firms attempted to serve as a bridge to other clusters. Examples of the former are Tesla and BYD, who invested in the larger share of the EV ecosystem. For the latter case, network links such as found for Johnson Controls, Smith (acquired by Tanfield) and Azure Dynamics (Figure 3-4) for cooperation and future competition models [151] highlight another approach for higher ecosystem influence. Azure and Smith additionally engaged in a joint venture to develop hybrid electric powertrains for commercial and military vehicles. The business functions of these three companies represent unique components of the EV supply chain (Li-ion battery manufacturer, electric power trains and EV OEM), thereby suggesting an ecosystem strengthening approach attempt for competitive advantage [156] [38].

In contrast, Tesla and BYD are linked only by FMR LLC (Figure 3-5), a privately owned investment manager [150]. Tesla-led ecosystem through an exclusive alliance with Panasonic's Gigafactory initiative produces all its Li-ion battery needs in-house i.e. possessing the combination of both Li-ion batteries supply and EV OEM capability. The Tesla-led ecosystem and BYD-led ecosystem, though suppliers to geographically separated markets, can be considered direct competitors. Their link via FMR LLC is not an unusual financial investment strategy that believes in the emerging global industry and chooses to gain from the simultaneous growth of the same product in different regional markets and hedging financial risk in the process [157].

The deals network analysis method used in this study served as a pointer to identifying hub firms related to the emerging EV industry. Among the hub firms that were conglomerates, a majority of the deals were found to be unrelated directly to building their capabilities for EV

related products and services, possibly suggesting a wait-and-watch approach. However, identification of such hub firms is relevant as they could be positioned to scale on demand.

The hub firm Phillips & Temro Industries Inc. (PTI) with over 10 firms in its network was found to be unrelated to the EV industry and appeared in the shortlist as a minor supplier of battery warming systems and battery heater wire harnesses.

The deals types contained a large share of pure financial transactions between subsidiaries, shareholders and investors which could imply in some cases additional capital sourced for EV related R&D activities. Ensuring an edge in competitive positioning could be a possible reason for firms to choose not to publicly declare specifics of their research achievements [158]. For a better historic assessment of early research linked EV capability building, interviews with key personnel of the hub firms could be a more effective measure of ecosystemic strategy. Firms also navigate through market and leadership making not necessarily consistent from a longer period perspective. This aspect may further add noise in deals data for the objective of this study.

Deals data used may not include comprehensive coverage of certain relevant initiatives and collaborations that were not classified as publicly declared deals. An example of such an

Table 3-4 Electric Vehicles Value Chain coverage of Hub Firms

<b>Value Chain Actor</b>	<b>Core Capability</b>	<b>Hub Firm</b>
<b>Vehicle Manufacturer</b>	EV OEM	Tesla, BYD, Smith (Tanfield), GND, CH-Auto
<b>Component Supplier</b>	Li-ion Batteries	BYD, Avic (including supercapacitors), Valmet
	Electromechanical Braking Systems	Haldex
	EV Motors and Generators	Teco
<b>Raw material Supplier</b>	Lithium Supply	BYD (through minority stake and joint venture in China)
<b>Processing component</b>	EV Assembly Production Systems	Valmet
<b>Complement</b>	Services during driving	CH-Auto
	Lease financing	Tesla
<b>Infrastructure Complement</b>	Power Distribution System Suppliers	ZTT
	Renewable Power Generation Equipment Suppliers	Avic, Teco, Tesla
	Electric Power Trains	Azure, Valmet
	Charging Station equipment and components suppliers	Hangzhou Zhongheng Electric Co. Ltd., Ecotality, Tesla

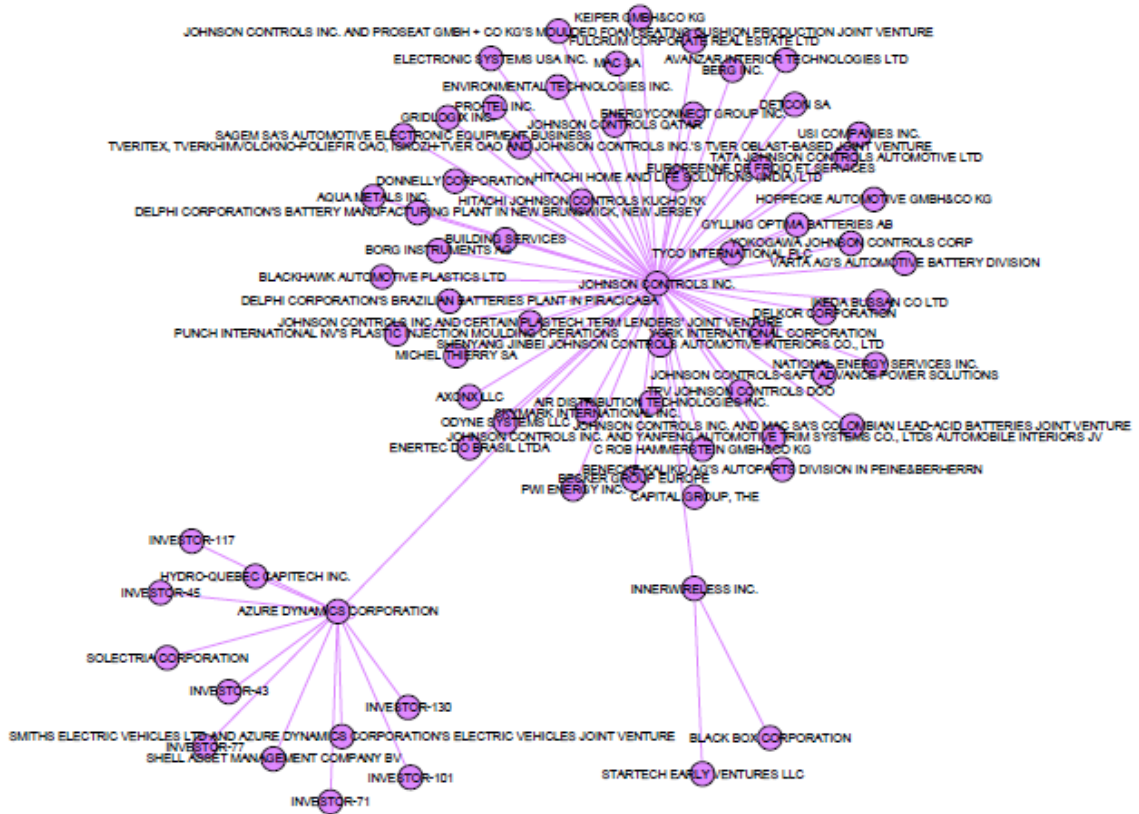


Figure 3-4 Network links between Johnson Controls, Smith and Azure Dynamics

occurrence is the previously mentioned EV products development and testing by Haldex AB. Another example is CH-Auto’s agreement with Navinfo for joint business development and strategic deployment for autonomous driving and IoV (Internet of Vehicles).

The system integration of vehicle system architecture for autonomous driving, a key enabler for the EV industry, involves technology collaborations between vehicle OEMs and system suppliers such as for braking, steering, powertrain, HMI telematics and intelligent sensors based communication. The major technology stakeholders of such collaborations include firms like Delphi, Bosch, Volvo and Daimler and several others that did not appear prominently in the deals network analysis. Other missing stakeholders are critical actors of the EV promoting ecosystem such as municipalities for testing, parking and charging infrastructure, shared transportation business models (e.g. Uber) and smart power grid that are innovating in tandem in select geographical pockets. The co-innovation dependency on such actors is a necessary characteristic of emerging ecosystems [26].



firms are formidable EV industry actors, combining deals related information from Chinese sources that are not reported globally can substantiate the results from deals network analysis. Another approach to evaluating accuracy of deals analysis method for ecosystemic insights is to compare with results from non-deals sources of leading EV firms such as financial statements and press releases.

We identified a typology of hub firms' propensity to enter or expand their role within their ecosystem. This typology consists of strategies for components portfolio expansion, upstream and downstream integration, technological threats motivated diversification and market entry. Incentives by some countries of operation of hub firms as influencers especially China and the Republic of Korea can be attributed to their faster growth. Lack of equivalent incentives was overcome by technological advancement push by USA firms. The fact that hub firms can originate from different value chain functions is established. Another formation dynamic identified is the presence of some hub firms in multiple value chain functions suggesting higher risk appetite for tighter controls for governing the ecosystem. The aspect of links between ecosystems is highlighted as a dynamic that could progress as a cooperation model to further strengthen ecosystemic forces.

The emerging global EV industry manifests a public mobility system in transition. The industrial dynamics occurring in this transition are evident in the types of technological and business strategies adopted by each hub firm identified in this study. The technological substitution pathway and the co-evolution [160] from ICE engines to electric drive is visible at different rates from a country perspective. The data for China suggests two factors: impact from rapid urbanization and resulting pollution in major cities affecting public health; and domestic policy support favoring opportunities in trade for EV batteries and raw materials (particularly lithium). The data for the US suggests advances in EV related technology is related to a cycle of technological substitution that is influenced by policy makers through R&D and industrial policy. Policy makers can continue to co-design the regime with stakeholders based on credible developments in regional pockets and understanding of business ecosystem dynamics.

### **3.6 SUMMARY**

The global deals network analysis approach in this study has revealed clusters, types of EV related activities and their respective hub firms based in USA, Sweden, UK, China, Finland, Taiwan and the Republic of Korea. The primary business functions of the hub firms ranged from vehicle manufacturers, components suppliers (Li-ion battery, motors and power distribution products), systems suppliers (electromechanical systems including braking, electric power trains, EV charging stations and renewable energy generators) and oil /gas producers. Several hub firms offered multiple EV related business functions, thereby controlling a larger share of the total ecosystem. BYD Co., Ltd. adopted the strategy of controlling the largest ecosystem share that included early upstream supply chain integration (sourcing and producing lithium / Li-ion products) and downstream capability development of vehicles assembly. BYD additionally benefited from the favourable regional environment of Chinese policies and incentives that promoted investment. Open vehicle system architecture commitment by Haldex through integration of renewable power supply for EV charging, EV, battery and charging stations under one umbrella, etc. was another example of ecosystemic strategy with partners. Some hub firms in USA and EU regions appeared to be less active in EV industry investment and retained focus on mature businesses – potentially because of a of relatively less favourable regional investment environments. Nevertheless, these firms contributed to enhancing core EV technologies.

## **4. CASE STUDY OF IOT LINKED ECOSYSTEMS**

### **4.1 INTRODUCTION**

Firm strategy guidance in the digital age is challenging with numerous links for delivering a superior service to the end consumer, some of which are not readily visible. The firms and other entities involved in virtually every type of service offering are not only growing but also already in large numbers. The geographical distinctness in terms of markets, financing and regulations are challenging to interpret for startups and incumbents to survive and thrive. In this prevailing business environment, digital technologies and industries emerging from the Internet of Things (IOT) paradigm are among the more pervasive and transcend traditional industry sector boundaries. Industry sectors such as online retail, telecom, satellite communications, industrial and consumer applications in utilities are early stakeholders of the IOT ecosystem.

In this study, we aim to derive heuristic firm strategy guidance that is representative of the complexity of size, pace, regions, sectors and other facets related to IOT ecosystems. For this purpose, we utilize publicly declared global deals of firms related to IOT such as acquisitions, joint ventures, investments and other formal alliances. In the following sections, we propose a method for deals network analysis of the IOT linked firms that reveals major clusters and their respective hub firms. Based on the results, we validate that the clusters are exclusive with minimal inter-cluster interactions and proceed with their hub firm profiling. The hub firms are found to be non-competing. An incumbent firm can enter into alliances for exploration on one hand and better market orientation on the other hand. Exploration alliances have been defined as technology-based delivery supply chain activities, while market oriented alliances have been defined as customer facing non-technological activities such as marketing and sales [161] [162] and technologies enabling them when applicable. The respective rationales of deals of the hub firms are enumerated as innovation strategies. Finally, their innovation strategies are categorized in a market-oriented vs. technology-seeking inclination framework that offer strategy guidance for ecosystem firms.

### **4.2 LITERATURE REVIEW**

Firms build dynamic competencies through R&D initiatives for a range of exploratory goals that include short or longer horizon, incremental or disruptive innovation, or certain

combinations of them. During intervals of rapid and widespread technological change, the best performing firms tend to revise their R&D portfolios to include more explorative R&D expenditure as compared to exploitative [163]. A firm's long and short horizon survival and prosperity in a changing environment is closely linked to maintaining an appropriate balance between innovation [164]. In this study, exploitation of known certainties is referred to as the focus on market orientation.

Market orientation as an organizational strategy has been related to higher business performance, especially during times of market turbulence and greater competitive intensity [165]. In stable and predictable environments, market orientation facilitates efficiency of delivering products and services. The regulated large technological system of telecommunications, for example, within its innovation regimes favors incremental improvements that are symbiotic or complementary to existing services [166]. This innovation tendency seeks to expand the number of subscribers which in turn increases the value to the existing base. The overall effect is promoting technology stability, therefore strengthening the existing market base [167]. Conversely, during periods of technological turbulence, market orientation in absence of exploration has been found to be negatively correlated with business performance [165]. Ambidexterity between market orientation and exploration is therefore widely advocated in literature, and it is additionally observed that this ambidexterity can be linked to the balance between market pull and technology-push [159] [24] [168] [169] [170] [171].

Exploration is associated with challenging of the status quo and developing of new knowledge related to products, technologies, skills and new markets. Firms in technology intensive industries such as semiconductor manufacture, can be expected to engage more in exploratory R&D to defend their oligopolistic positions [172][173]. Such exploratory designs when combined with enhancement and invention of products, also include initiatives that derive unmet (latent) customer needs [174]. In contrast, market-oriented strategies have been differentiated as refinement-led or emphasizing utilization of knowledge. Market-oriented actions by firms include initiatives to expand their product portfolio relative to competitors, to access new markets or regions with existing products, and to expand services that support conventional sales and marketing [162]. Firms that engage in exploration, while excluding market orientation, may accumulate too many undeveloped ideas through expensive experimentation without realizing the benefits. Conversely, with little focus on exploration, firms risk future viability. To achieve a balanced compromise, it has been suggested that firms

should search for knowledge in areas that extend their current competencies and capabilities slightly beyond their short term relevance horizon belief [175]. Market-orientation and knowledge-seeking are also intricately linked. While it is expected that a number of explorative innovations over time convert to market value to firms, it has been suggested that market oriented innovations can lead to complementary explorative learning [175] [176] [177].

Striking the right balance between market-orientation and exploration and maintaining this balance over periods of market and technological change, requires the additional dimension of organizational generative learning capability [171] and entrepreneurial orientation [174]. In this study, firm specific factors such as organization design, earning, capability, management, leadership and entrepreneurship are excluded. For certain business sectors, the dimension of regulatory push or pull can significantly influence innovative behavior [178]. While regulatory environment for IOT linked products and services such as cybersecurity and numerous other standards are crucial for dominant designs to evolve and be adopted on mass scale, this dimension is also excluded from the scope of study due to focus on ecosystem formation stages.

In a similar manner to internal R&D investment, firms advance their market-oriented and exploration agendas through deals with external firms such as mergers, acquisitions, joint ventures or minority stakes. Engaging in a high number of such deals offers an advantage to firms through a variety of parameters. The relationship between deals and innovativeness has been investigated in literature in terms of forecasting the innovation potential [179], impact of M&A on innovation strategy [180], product development path [162], absorptive capacity and organizational inertia [181] [182], acquired product capital [183], and alliances vs acquisitions for external knowledge sourcing [184]. In this study, we leverage publicly declared deals data to offer an empirical basis for revealing innovation strategy of firms linked to business ecosystems emerging from the IOT paradigm. The sectors emerging from IOT technologies is a unique case study where new and established firms collaborate [185]. Several studies have proposed IOT capability building through ambidextrous alliances for product and process innovation [186], smart city public-private alliances [187], open innovation [188], partner selection [189], links between IOT and 5G vendors and operators [190].

For the case of IOT products and services, the exploration agendas of firms are predominantly technology-seeking. Hence, IOT linked firms identified in our deals network analysis are mapped on a framework that contrasts market-orientation vs. technology-seeking inclination.

### 4.3 DATA AND METHODS

Data on global M&A, IPO, private equity and other formal alliances between firms was sourced from Zephyr Database of Bureau van Dijk Electronic Publishing (BvDEP) [191]. Zephyr data is populated from advisor submissions, company press releases, various electronic publications of business news, stock exchanges and company websites covering over 1.6 million completed, announced and rumored deals. A study comparing Zephyr to its closest competitor SDC Platinum (currently Thomson Reuters M&A Database) has highlighted Zephyr to be better suited for more details on precise enquiries [104].

Zephyr M&A data has been utilized in a variety of publications that include post merge financial trends, performance and social impact [105] [106] [107], analysis of public-private vs. private-private deals [108], legal origin of M&A deals [36], rationale of deals categorization for innovative advances [110] [111] [112] and M&A trends by industry sector [113]. Prior research of the authors has explored the global electric vehicles business ecosystem using Zephyr data, which shares with this study the methodological approach as described below.

Data retrieved on September 18th, 2019 by querying for “internet of things” in the global search option of the Zephyr platform found 4,676 deals. Each deal included several fields of metadata including deal status and deal type. Deal status indicates classification as announced, completed, assumed completed, pending, rumored or withdrawn. This study analyses only those deals that are completed or assumed completed, which hereafter are referred to as “deals”. Deal type includes acquisition, IPO, minority share increase, institutional buy-out, management buy-out, capital increase, share buy-back and joint venture. All deal types are analysed.

Prior to the analysis, certain data preparation steps were conducted. For those deal types where a single company transaction is involved such as IPOs, capital increase and minority stake increase, the target company name was copied as the acquirer company name. This was done to avoid the blanks output in the data set. Additionally, Zephyr describes certain investor types with a generic label like investor, investors, private investors, etc. Thirty six such generic labels were found repeated in the data set, which would be interpreted as unique entities in the aggregated statistics and skew the analysis. To correct for this, a numeric identifier was appended to the generic labels.

Post data preparation, a network of deals was created. Acquirer and target act as nodes and a connection was established between them if they had undertaken a deal. As this study is focused on the number of deals of each company, the direction of the deal was ignored.

Companies closely connected with relatively larger number of deals were spotted as clusters. These clusters of companies were decomposed using the Louvain algorithm [58] to identify hub firms of each cluster. The hub firms represent not only the most active deal-making firms associated with leveraging IOT technologies, but also ones that exhibit higher connectivity in the network or degrees. These firms were shortlisted for deeper profiling based on the rationale of their deals and supporting news sources. The learnings were collated by business functions of the firms' network and the resulting insights are summarized as ecosystem firm strategy guidelines.

## **4.4 RESULTS**

### *4.4.1 Clusters of Deals Activity*

Deals of IOT linked firms started in 1997 and steadily increased to the date of retrieval in 2019 (Figure 4-1). The deals were 4,676 in number between 3,757 firms, out of which 3,908 (83.6%) were completed or assumed completed. Most of the deals were related to minority stake purchase, followed by acquisitions, capital increase, IPO and others as listed in Table 4-1. On conducting the network analysis, it was found that the deals (or edges) in the network were 96% intra-cluster and 4% inter-cluster. The 4% inter-cluster deals were with investment banks and financial institutions. As cluster level analysis was almost identical to hub firm analysis, we characterized the clusters based on their respective hub firms. To focus on ecosystems that have evolved significantly, we identified the outliers, which are defined herein as hub firms of clusters having over 10 firms in their networks. Based on this criteria, 28 clusters were revealed that are visually illustrated in Figure 4-2. Table 4-2 lists the characteristics of these 28 clusters in terms of number of firms within them, number of deals they made, the average year and profiling parameters of their respective hub firms.

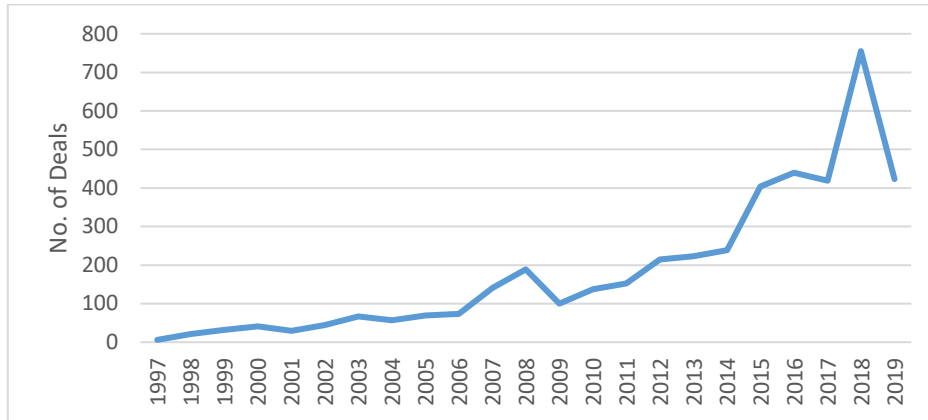


Figure 4-1 Deals trend of Internet of Things linked firms

Table 4-1 Types of transactions involved

Type of Transaction	Deals
Minority Stake	1904
Acquisition	1010
Capital Increase	403
Initial Public Offering	167
Share Buyback	142
Joint Venture	136
Minority Stake Increased	83
Institutional Buyout	29
Management Buyout	10
Funds injection into subsidiary	10
Investor Shares Sale	10
Merger	3
Demerger	1
<b>TOTAL</b>	<b>3908</b>

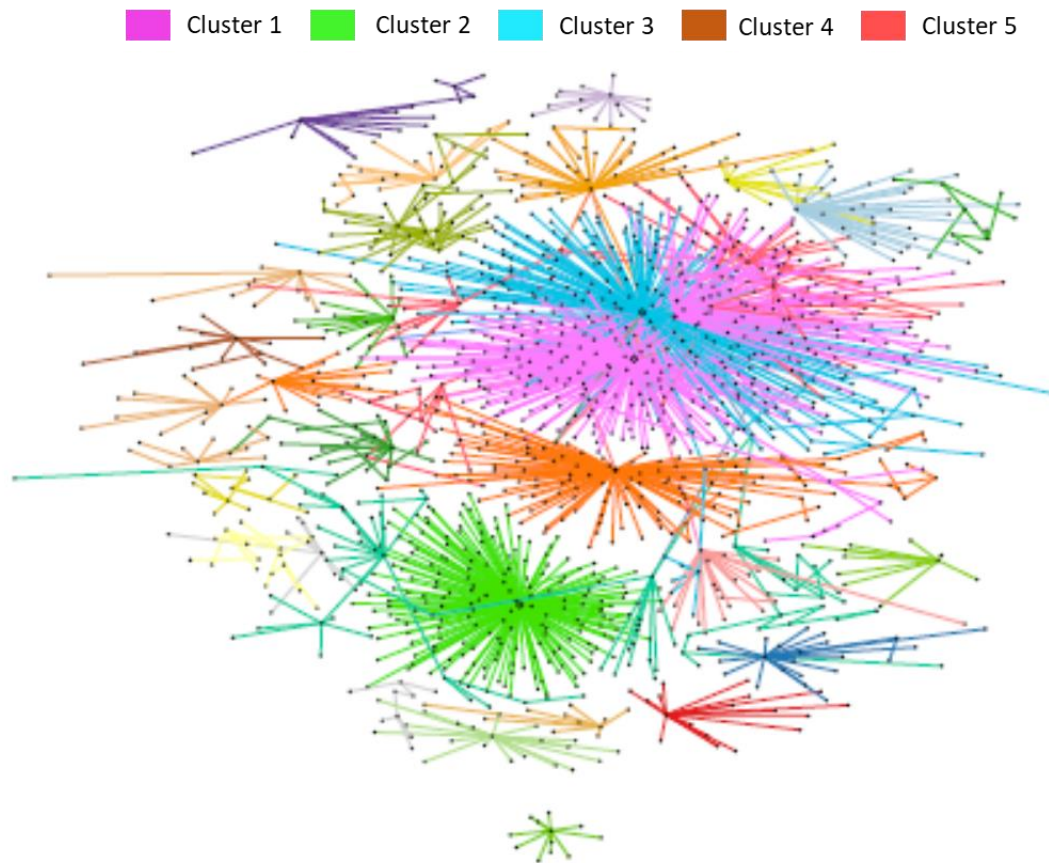


Figure 4-2 Deals network of Internet of Things linked companies (1,354 firms grouped into 28 clusters, major clusters are highlighted in legends)

#### 4.4.2 Hub Firms Profiling

The 6 business functions represented by the companies in the 28 clusters with degree of 10 or higher in descending order were Retail; Industrial, Electric & Electronic Machinery; Computer Software; Computer Hardware; Communications and Business Services (Figure 4-3). The category of “Banking, Financial Services & Insurance” was excluded from this list, as this category was verified to be catering mostly to financial investments for the growth of the clusters rather than resulting in own IOT linked applications. The clusters 7, 19 and 25 were therefore filtered out by the criteria applied. The clusters with combined degrees of over 50 were selected for analysis to focus on outliers. For reference, clusters 1, 2, 3, 4 and 5 had combined degrees of 291, 198, 193, 114 and 61 respectively. Some clusters were found to include more than one hub company. Clusters 1, 2, 3, 4 and 5 have 2, 1, 1, 1 and 4 hub firms respectively. Cluster 6 is a far follower with 2 hub firms with combined degrees of 26 and not considered from a threshold perspective for analysing trajectory growth for the time of retrieval

of the data. A quantitative profile of the hub firms of the selected 5 major clusters is summarized in Table 4-3.

The rationale of deals executed by the 5 selected clusters and their respective hub firms are analysed in the following sub-sections to identify their strategic motivations and reasoning for dominance of their business categories over others.

Table 4-2 Characteristics of Hub Firms of the largest IOT linked clusters of the deals network

Cluster ID	Firms in cluster	Deals made	Average year	Hub Firms	Hub's Country	Zephyr Business Category	Degrees
1	281	512	2015.6	AMAZON.COM INC.	USA	Retail	197
				SALESFORCE.COM INC.	USA	Computer Software	94
2	200	416	2011.8	HTC CORPORTION	Taiwan	Communications	198
3	190	234	2011.8	INTEL CORPORATION	USA	Industrial, Electric & Electronic Machinery	193
4	133	377	2010.7	KONINKLIJKE KPN NV	Netherlands	Communications	114
5	74	98	2013.5	PTC INC.	USA	Computer Software	18
				ITRON INC.	USA	Industrial, Electric & Electronic Machinery	17
				SEMTECH CORPORATION	USA	Industrial, Electric & Electronic Machinery	14
				ORBCOMM INC.	USA	Computer Software	12
6	70	89	2013.9	INTEL CAPITAL CORPORATION	USA	Banking, Insurance & Financial Services	16
7	42	83	2015.6	SOPHISTICATED INVESTORS	Various	Banking, Insurance & Financial Services	10
8	38	46	2010.9	MENTOR GRAPHICS CORPORATION	USA	Computer Software	11
9	30	34	2011.5	WEST CORPORATION	USA	Computer Software	37
10	23	32	2009.8	GREEN PACKET BHD	Malaysia	Communications	29
11	21	22	2006.7	NESS TECHNOLOGIES INC.	USA	Computer Software	20
12	21	35	2015.1	SHENZHEN INVT ELECTRIC CO., LTD	China	Industrial, Electric & Electronic Machinery	15
13	20	23	2009.1	SILICON LABORATORIES INC.	USA	Industrial, Electric & Electronic Machinery	19
14	18	19	2011.7	GUANGXI LIUGONG MACHINERY CO., LTD	China	Industrial, Electric & Electronic Machinery	16
15	17	18	2002.5	CMGI INC.	USA	Business Services	12
16	17	16	2008.1	PARAMETRIC TECHNOLOGY CORPORATION	USA	Computer Software	16
17	16	18	2015.8	LUXOFT HOLDING INC.	Virgin Islands (British)	Computer Software	15

<b>Cluster ID</b>	<b>Firms in cluster</b>	<b>Deals made</b>	<b>Average year</b>	<b>Hub Firms</b>	<b>Hub's Country</b>	<b>Zephyr Business Category</b>	<b>Degrees</b>
<b>18</b>	16	16	2016.0	SHENZHEN H&T INTELLIGENT CONTROL CO., LTD	China	Industrial, Electric & Electronic Machinery	11
<b>19</b>	16	18	2012.4	MANAGEMENT (of same firm)	USA	Business Services	5
<b>20</b>	14	33	2017.7	GOLDEN SPRING INTERNET of THINGS INC.	China	Industrial, Electric & Electronic Machinery	11
<b>21</b>	14	15	2008.4	DIGI INTERNATIONAL INC.	USA	Computer Hardware	13
<b>22</b>	13	13	2016.8	CERTUSNET INFORMATION AND TECHNOLOGY CO., LTD	China	Computer Software	12
<b>23</b>	12	15	2008.3	JDA SOFTWARE GROUP INC.	USA	Computer Software	11
<b>24</b>	12	8	2008.4	HUAWEI TECHNOLOGIES CO., LTD	China	Communications	11
<b>25</b>	12	15	2006.2	LANTRONIX INC.	USA	Communications	6
<b>26</b>	11	15	2009.4	GLOBECOMM SYSTEMS INC.	USA	Communications	10
<b>27</b>	11	14	2016.1	ZHISHENG LIANFA INFORMATION TECHNOLOGY CO., LTD	China	Computer Software	10
<b>28</b>	11	10	2017.3	LIERDA SCIENCE & TECHNOLOGY GROUP CO., LTD	China	Computer Software	10

Table 4-3 Profile of Hub Firms of Top 5 Clusters

Cluster	Hub Firm	Deals <sup>1</sup>	Companies	Countries	Business Categories <sup>2</sup>	Average Year	Reported Deals Value (Euros) <sup>3</sup>
1	AMAZON.COM INC.	387	197	21	12	2015.40	€ 40,416,354
	SALESFORCE.COM INC.	134	88	10	5	2015.03	€ 20,018,734
2	HTC CORPORATION	620	199	10	8	2011.85	€ 14,962,372
3	INTEL CORPORATION	290	194	29	13	2011.80	€ 66,716,633
4	KONINKLIJKE KPN NV	559	115	15	13	2010.79	€ 86,830,235
5	PTC INC.	25	19	4	3	2016.04	€ 1,702,615
	ITRON INC.	30	18	6	4	2010.17	€ 3,985,818
	SEMTECH CORPORATION	29	15	6	4	2013.62	€ 791,494
	ORBCOMM INC.	24	13	5	5	2013.67	€ 637,879

<sup>1</sup>Deals counts include hub firm as both acquirer and target. Target in this case refers to financial transactions within the same firm. The study in this paper focuses on hub firm deals as an acquirer.

<sup>2</sup>Business Categories considered as Zephyr classification of business categories

<sup>3</sup>Only sum of reported values are included. Some deals values are not disclosed

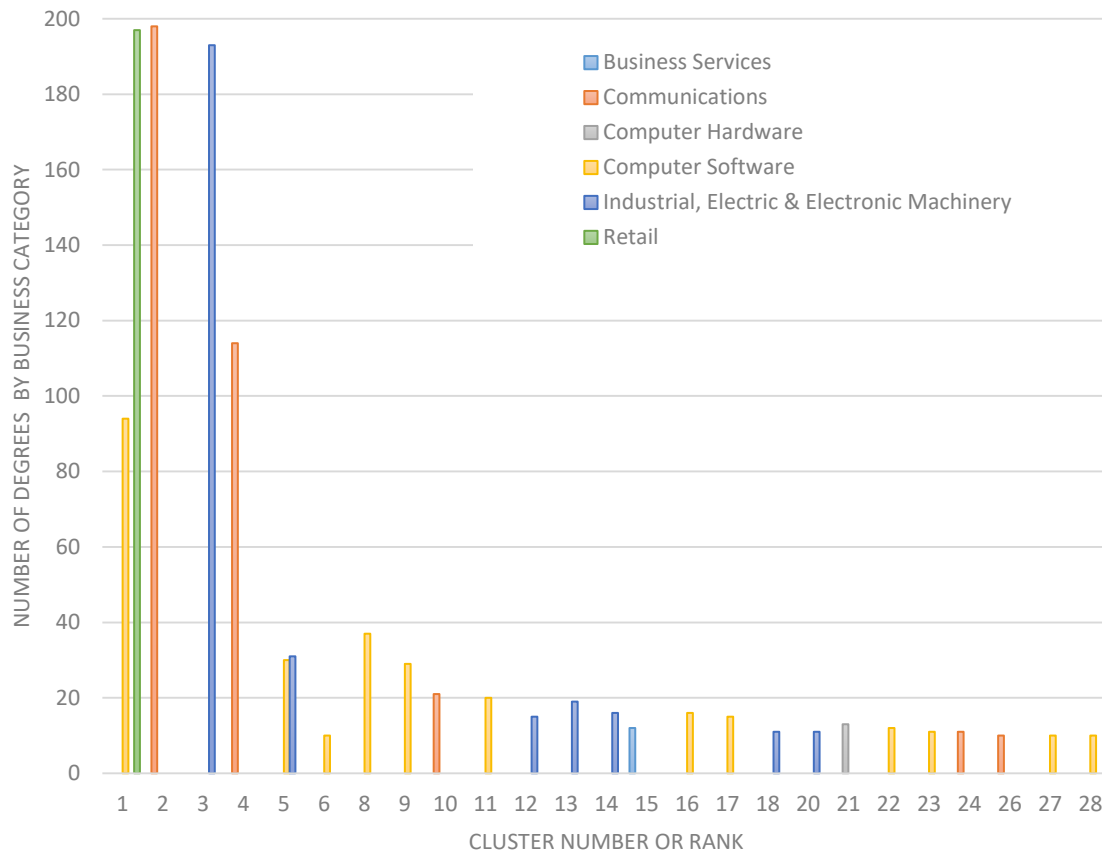


Figure 4-3 Business Functions of Top 28 Clusters of IOT related deals<sup>5</sup>

(10 or higher degrees or number of connected companies of each category; Financial investor groups are excluded)

#### 4.4.2.1 Cluster 1 Hub – Amazon.com Inc., Salesforce.com Inc.

Cluster 1 was represented by two major US based hub firms, namely, Amazon.com Inc. (Amazon) in the business of retail and Salesforce.com Inc. (Salesforce) in the business of computer software (Figure 4-4). The number of firms that Amazon and Salesforce were connected to or their degrees are 197 and 94 respectively (Table 4-2).

Amazon, founded in 1994, is the world’s largest retailer as measured by a composite score of revenues, profits, assets and market value [192]. Broadly, Amazon’s business is centred around e-commerce, cloud computing, digital streaming and artificial intelligence. Their business categories of operation today are Shop amazon.com, Amazon Web Services, Prime Video, Amazon Music, Fire Tablets, Fire TV, Echo and Alexa, and Kindle E-readers and Books

<sup>5</sup> The clusters 7, 19 and 25 were filtered out due to the applied criteria of including clusters containing firms with 10 or higher degrees and excluding the business category of “Banking, Financial Services & Insurance”.



Figure 4-4 Cluster 1 – Amazon.com and Salesforce.com

[193]. Broadly among their business categories, AWS is business-to-business (B2B) and a major contributor to the total revenue [194], while all others are business-to-consumer (B2C) retail of both others' products and services and own physical and digital products and services. Amazon which started off as an online retailer and dominated over physical stores, now also operates brick and mortar businesses through Whole Foods, Amazon Book Stores, 4-star stores and Amazon Go [195]. Their innovation strategy has involved investments and acquisitions that leverage technology to strengthen their existing products portfolio and their complementors including fostering ecosystems of small and medium enterprises (SME) and influencing communities. Their deals have also prepared them to enter new markets, though not all were obvious at the time and some even today.

Amazon had 138 completed or assumed completed deals, out of which 56 were acquisitions, 46 were minority stakes, 13 were capital increases, 10 were investor shares sale and 3 were investor share buyback. Out of 56 acquisitions, 40 were with US firms, 5 with UK firms and 1 each with firms in other 11 countries. Though the 56 acquisitions have few functional overlaps, a classification based on known existing products of Amazon is applied in Table 4-4 for strategic insights.

The minority stake deals included investments in core retail products, enabling technologies and some related to new products as listed in Appendices Table A1. Out of 46 minority stakes, 34 were with USA based firms, 6 with India based firms and rest single firms in UK, Israel,

Table 4-4 Summary of Amazon's functional acquisitions

<b>Products / Services</b>	<b>Acquired Function</b>	<b>Deals</b>
Amazon.com - Online Retail Portfolio	Online Books; Diversified Retail; Audible Books [196] [197]; TV Sports Broadcasting [198]; Pharmaceuticals; Baby Products; Online Music; Fabrics; Online Video Streaming; Home Security & Smart Home products [199]; Shoes; Lighting Equipment; Video Games [200]; Movies, TV, Games	21
Amazon.com - Online Retail Sales	Online community for book lovers; Shoe measurement comparison software; Video Games developer application; Sales campaigns & promotions enhancement [201]; Online book readers social networking website; 3D body models application for Apparel, Fashion; Bringing social interactions and conversations into online shopping experience [202] [203]; Digital Cameras reviews	8
Amazon.com - Online Retail Logistics	Shelving robotics & autonomous carts [204]; Material handling, warehouses and fulfillment operations automation; Facilitation of goods import into US [205]	3
Amazon.com - Online Retail UX	eBooks reading application [206] [207]; Enhanced user experience across connected devices [208]	3
Alexa	Chatbots for Conversational Commerce [209]; Online trending visualization search content platform [210]; High accuracy -automated speech recognition platform for long duration dialogues [211] [212]	3
Mobile Payment	Online Payment Technology [213]; Regional Online Payments enablement [214]	2
Amazon Web Services (AWS)	New service utilization model [215]; Unstructured data acquisition & analysis for Amazon Redshift [216] [217]; Cybersecurity Tool [218]	3
Educational Services	Teacher and student online matching & education services; online innovative mathematics curriculum platform [219]	2
Amazon Physical Stores	Organic foods retail; Enterprise IOT Platform Middleware [220]	2
Kindle Fire	Mapping service [221]	1
Amazon Photos, Drive Apps, AWS	Photo recognition technology [222] [223]	1
Kindle Fire; Alexa	Speech synthesis solution [224]	1
Kindle eReaders	Screens that can handle "all lighting conditions" for mobile devices [225]	1
Amazon Echo	Question answering capability enhancement [226]	1
Amazon.com (Online Retail); Alexa; Cloud Cam	Home Security & Smart Home [227]	1
Unclassified	Machine translation solutions; Assistive Technology for Visual Access Needs; Lighting equipment	3
<b>TOTAL</b>		<b>56</b>

Brazil, Turkey, Germany and France. Capital increase deals of 13 included 6 that were funded by The Alexa Fund, Amazon's voice technology focused innovation fund [228]. The funding principles of the Alexa Fund, while agnostic to startups and established brands, require leverage of Alexa Voice Service (AVS) and Alexa Skills Kit (ASK) in hardware and software or contribution to science of voice technology and its enabling components. In turn, Amazon promotes their products or services by introducing them through their marketing channels and providing infrastructure support. Thus far, the Alexa Fund has been successful in 10 exits [229], among which not all were tagged as IOT linked. Out of the remaining 7 out of 13 capital increase deals, 3 were investments made by Amazon into its subsidiaries in India and 4 were investments in niche product firms that include pdf document management, robotic equipment control and mobile location management. This latter group of 4 capital increase deals signalled Amazon's interest in exploring niche areas similar to their minority stakes deals, hence also included in Appendices Table A1. Amazon's 10 share sales and 3 share buyback deals by its investors were financial methods likely to release funds for funds injection and / or re-invest in other initiatives, reduce debt burden or raise lower cost debt.

Salesforce.com Inc. (Salesforce), founded in 1999, is a global leader in Customer Relationship Management (CRM) software solutions [230]. They pioneered the use of cloud technologies for CRM, making the information available anytime and from anywhere. They integrated mobile devices to their services and now apply Artificial Intelligence (AI) technologies for more predictive and personalized customer information [231]. They offer a platform for ecosystem members to engage on marketing, sales, commerce, service, IT and other customer interface related transactions. They have focused on delivering value to small and medium business enterprises (SME), that were previously less serviced by enterprise CRM solutions.

Salesforce had 68 completed or assumed completed deals, out of which 42 were acquisitions, 6 were capital increases, 19 were minority stakes and 1 was Initial Public Offering (IPO). Out of 42 acquisitions, 35 were with US firms, 2 each with firms based in France and Canada and 1 each with firms based in Japan, Israel and Germany. Acquisitions of Salesforce have primarily been in online technology enhancement around developing a social enterprise with more productivity and intelligence. 19 acquisitions out of 42 were related to cloud computing, consumer data management, enterprise analytics and social media marketing. 1 acquisition was for an AI Platform. Others acquisitions were around strengthening the core product such as with cybersecurity, online data entry and collaborative document editing, call

center operations, data integration, mobile data delivery, contact management platform, enterprise messaging, screen sharing, employee discounts, consumer user experience and web browser development. The 19 minority stake deals comprised of 15 with US firms, 3 with Japan based firms and 1 with Israel based firm. These deals were similar in nature to their acquisitions, in terms of primarily with CRM components related online technology firms related to data management platforms, file sharing, cybersecurity, mobile data delivery, payroll services, fieldwork-focused CRM, consumer user experience, contract management Quote-to-Cash (QTC), social networking, sales motivation, statistical analysis, API telephone communications, web applications and others. In addition, these minority stake deals included some non-CRM applications such as ridesharing and electronic health records management.

Amazon and Salesforce, hub firms of the same cluster, had no direct links between each other. However, with 1 degree of separation, their links include 275 deals with firms classified as Investment Advice (209 deals), National commercial banks (38 deals), Investors not elsewhere classified (21 deals) and Fire, Marine and casualty insurance (7 deals). Deals with Fire, Marine and casualty insurance function are minority stake deals as securities with a single firm American International Group Inc. In summary, cluster 1 hub firms are connected only through a relatively large number of common financial investor groups.

#### 4.4.2.2 Cluster 2 Hub – HTC Corporation

HTC Corporation (HTC), founded in 1997, is a Taiwanese consumer electronics company principally engaged in the design, manufacture and sales of smart phones and smart devices [232]. HTC was centrally located as a hub in Cluster 2 with 198 degrees (Figure 4-5).

HTC had 229 completed or assumed completed deals, out of which 21 were acquisitions and 208 were minority stakes. Out of 21, acquisitions, 7 were with British Virgin Islands based firms, 6 with Singapore based firms, 4 with US based firms and 1 each with firms based in France, Cayman Islands, Belarus and UK. HTC's acquisitions were mostly related to enhancement of their smart device products, which include computer components (6 acquisitions), software development (3 acquisitions), design for user appeal and experience (2), mobile digital media and content (1), accessories – headphones (1) and expansion of software applications (1). The remaining 7 acquisitions were related to funds injection and shares issues

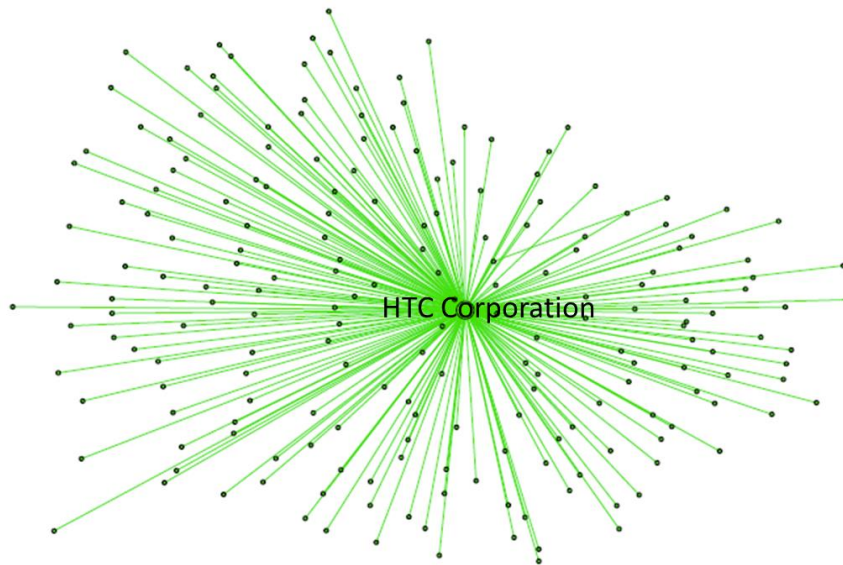


Figure 4-5 Cluster 2 – HTC Corporation

for their subsidiary holding company in the British Virgin Islands called HTC (BVI) Corporation. Out of the 208 minority stake deals, 204 were unspecified foreign investors selling shares of HTC, 1 was Taiwan

Tobacco & Liquor Corporation selling shares of HTC, 1 was Tong An Investment Co., Ltd, an investment unit of Taiwan-listed TECO, 1 was investment in Ddmap.com, a Shanghai-based electronic map provider and 1 was investment in OL2 Inc., a Palo Alto, California-based online gaming firm. The consistent HTC shares sale ranged from 2007 to 2016, with the highest numbers in 2012 and 2013.

The high volume of declining trend in HTC shares sale prompted an investigation into its history beyond the deals. HTC has been a pioneering company in multiple instances. In 2000, HTC released one of the earliest touch-screen smartphones; in 2002 created the first Windows smartphone; in 2005 it helped usher in 3G; in 2008 it released the first Android phone; in the following years launched the first US 4G phone and helped design Google's first-ever smartphone (Nexus One) [233] [234]. In 2010, HTC was one of the most innovative companies and smartphone brands competing with Apple [235]. The downfall of such a pioneering and continuously innovating company has been attributed to their judgements in lesser marketing focus, untimely portfolio diversification investments and inadequate competitive responses [236]. HTC has also been embroiled over patent litigations with Apple [237], which likely contributed to investors uncertainty.

#### 4.4.2.3 Cluster 3 Hub – Intel Corporation

Intel Corporation (Intel), founded in 1968, is a global major semiconductor chip manufacturer. Intel has leveraged its hardware capability for various consumer applications. Intel, whose business is classified as Industrial, Electric & Electronic Machinery, was a central hub firm with 193 degrees (Figure 4-6).

Intel had 157 completed or assumed completed deals, with 82 acquisitions, 48 minority stakes, 15 capital increase deals, 11 joint ventures and 1 share buyback with its subsidiary. Intel's acquisition strategy is supported by their subsidiary Intel Capital Corporation, which facilitate its future business goals [238] including investments for accelerating internet usage [239]. Nine of the acquisitions by Intel Corporation included Intel Capital Corporation stake.

Intel's acquisitions were directed to enhancing specialized chips and integrated circuits (IC), specialized software and electrical components to support their hardware offerings, long-term vision of converged networks and communications, transitioning into their publicly declared AI capability [240] and technologies to support specific applications such as drones, system on chips (SoC), Natural Language Processing (NLP) and others. Table 4-5 summarizes their deals activity for each type of acquired function.

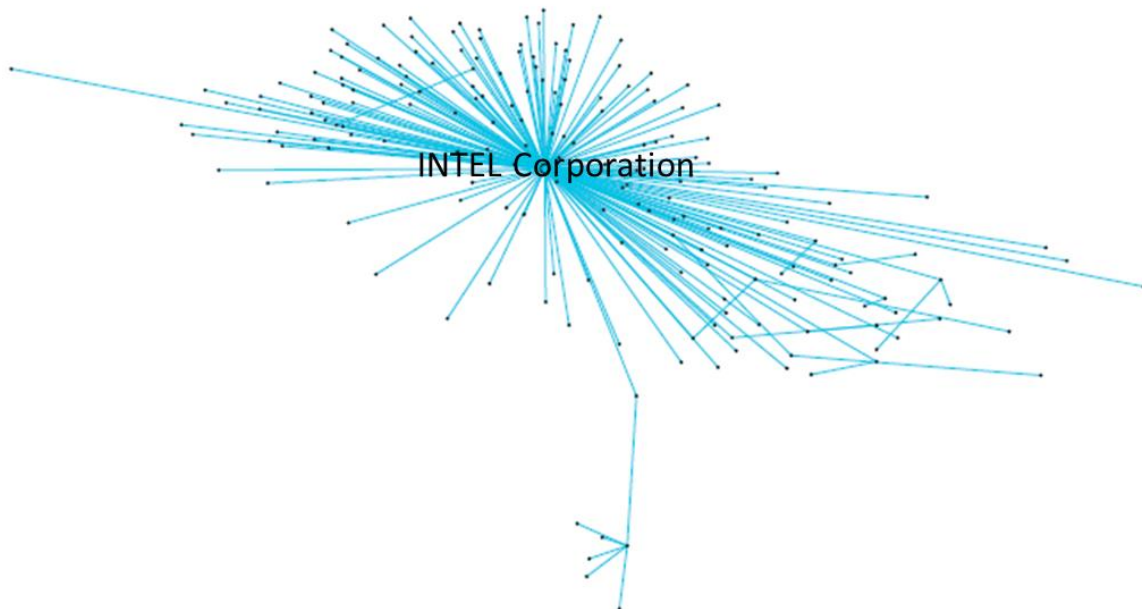


Figure 4-6 Cluster 3 – Intel Corporation

Table 4-5 Summary of Intel’s functional acquisitions

<b>Acquired Functions</b>	<b>Deals</b>
Specialized Chips & IC related	20
Specialized Software to support hardware & UI	17
Networking related	13
Drone related	2
System on a Chip (SoC)	2
Electric Components to support hardware	2
NLP related	2
AI related: Neural Network Processors; Software	2
Virtual reality; Smart Glass; HTML5 tools; Internet traffic control; Retail intelligence; Voice based eCommerce; Health tracking related; RF; Laser communications; Micro Optics Display (MOD) technology; Gesture recognition engine; Business Data Analysis; Mobile Location; Video 3D Reconstruction Technology; Biometric; Heart based biometetric; Global Navigation Satellite System (GNSS); Intelligent video & Vision; Scanning micromirror; Digital learning	27 (1 each)
<b>TOTAL</b>	<b>82</b>

Intel’s minority stake deals were mostly with similar business functions as acquisitions. Out of 48 minority stake deals, 14 were specialized software related, 8 were shares sold by investors, 6 were specialized chips & IC related, 3 were networking related, 2 were communications related and 1 was AI related. Other 11 deals included a diverse range of applications including online banking / financial services, healthcare, wine retail, virtual sports broadcasting, multimedia and others. 1 deal was related to China market expansion. Intel Capital had invested in 2 of the minority stake deals.

Intel’s 15 capital increase deals included 4 related to specialized chips and IC, 2 related to specialized software, 2 related to communications, 2 financial instruments to raise capital, 1 likely corporate social responsibility (CSR) related and 1 each related to drones, video eyewear, electric components and investment in own Chinese subsidiary respectively. Intel’s 11 joint ventures included 4 related to specialized chips manufacture in various global regions, 2 networking related, 2 communications related and 1 each related to tele-healthcare, home networking & security and integrated consumer systems, respectively.

#### 4.4.2.4 Cluster 4 Hub - Koninklijke KPN NV

Koninklijke KPN NV (KPN), also known as Royal KPN N.V., is a Dutch landline and mobile telecommunications company, with its history dating back to 1881 as a national telegraphy service [241]. KPN operates in Consumer, Business and Wholesales segments. For consumers, KPN offers communication, information, entertainment and commercial services



Figure 4-7 Cluster 4 – Koninklijke KPN NV

through single and multi-play offerings that include fixed and mobile internet, TV and telephony [242]. KPN subscribers include 3.6 million mobile, 2.9 million broadband, 2.2 million Interactive TV, 1.3 million Fixed-Mobile phone plans and 610,000 business multi-play [243]. For businesses, KPN offers fixed and mobile telephony and internet to a range of end-to-end solutions in core connectivity and close-to-core IT services such as cloud services, security and workspace. For wholesale partners, KPN provides connectivity solutions via our fixed and mobile networks. KPN’s has 114 degrees and its deals cluster is mostly central (Figure 4-7).

Table 4-6 Summary of KPN’s functional acquisitions

Acquired Functions	Deals
Telecommunication - Fixed Line, Internet, Broadband, Mobile, Radio, Video, Prepaid, Fibre Optic, Call Center, Networks, Business, Hosting, ISP, TV, CRM, Data Center and Other Services	36
Communications - Internet exchange port; Wireless Connectivity to web; Internet exchange; Internet based Voice; Video Equipment; Municipal	6
Medical Services related	4
IT Security, Connectivity, Automation	3
Retail - Online Events Tickets; Office Products Specialized Software	4
System Integration	2
Logistics – Automotive; Connectivity Software	2
Navy Maintenance Software	1
Narrowcasting Marketing	1
Shares repurchase of own subsidiaries; Financial Instruments	7
References not found	4
<b>TOTAL</b>	<b>70</b>

KPN had 277 completed or assumed completed deals, with 70 acquisitions, 80 minority stakes and increases, 3 capital increases, 7 joint ventures and 117 share buybacks. KPN's Acquisitions had primarily focused on expanding their market for the core business of telecommunications with relatively few exploring new technology enabled businesses. Table 4-6 summarizes their acquisitions profile. The 3 capital increase deals comprised of additional shares purchase of a Central and Eastern Europe internet service provider, equity and rights offering to raise capital. Out of the 80 minority stakes and increases, 71 were shares sale by KPN's investors, financial announcements, shares purchase of own subsidiary and 2 that were not identifiable. The remaining 9 minority stakes comprise of 6 related to telecommunications and communications market expansion, a specialized software, an online video portal and a logistics connectivity solution. The 117 share buybacks were conducted mostly by KPN and some by its investors.

#### 4.4.2.5 Cluster 5 Hub – PTC, Itron, Semtech and Orbcomm

Cluster 5 was well distributed and primarily represented nearly equally by the four hub firms – PTC Inc. (Computer Software), Itron Inc. (Industrial, Electric & Electronic Machinery), Semtech Corporation (Industrial, Electric & Electronic Machinery) and Orbcomm Inc. (Computer Software), in terms of the number of companies connected to each or their degrees of 18, 17, 14 and 12 respectively (Figure 4-8).

PTC Inc. (PTC), founded in 1985, provides tools for computer-aided design (CAD) modeling, product lifecycle management (PLM) and service lifecycle management (SLM) solutions for manufacturers and a suite of Internet of Things (IoT) solutions [244]. PTC had 10 completed or assumed completed deals, out of which 8 were acquisitions, 1 minority stake and 1 capital increase. All 9 deals were related to investment in specialized software strengthening PTC's portfolio of solutions such as software for PLM, Model-based Systems Engineering (MBSE), cloud based M2M, advanced data analytics, supply chain management, disparate devices and control systems, real-world photographic spaces 3D models and others.

Itron Inc. (Itron), founded in 1977 [245], provides products, solutions, software and services that measure, manage and analyze energy (electricity, gas) and water use [246]. Itron's solutions enable building of smart grids. Itron has 19 completed or assumed completed deals, out of which 13 were acquisitions, 3 were capital increases, 2 were minority stakes and 1 was share buyback. Out of the 13 acquisitions, 3

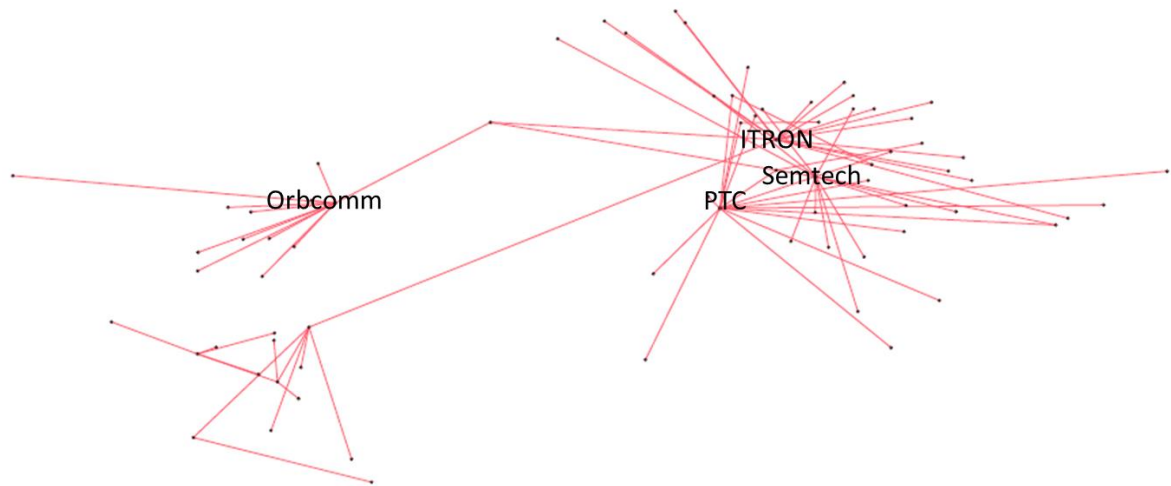


Figure 4-8 Cluster 5 – PTC Inc., Itron Inc., Semtech Corp. & Orbcomm Inc

were related to expanding meters and metering system portfolio, 6 were specialized software for energy intelligence, management and IOT connectivity for utilities industry, 2 were specialized services related to energy efficiency and demand, 1 for leak detection system and 1 related to smart grid technology. The 3 capital increase deals were related to shares sale by investor and financial instrument to raise capital. The 2 minority stake deals were related to expanding metering portfolio and specialized software for wireless workforce management.

Semtech Corporation (Semtech), founded in 1960, is a supplier of analog and mixed-signal semiconductors and advanced algorithms for consumer, enterprise computing, communications and industrial end-markets. Semtech's portfolio of semiconductor products has applications in automotive, broadcast equipment, data centers, passive optical networks (PONs), industrial, Internet of Things (IoT), LCD TVs, smartphones, tablets, wearables, and wireless infrastructure applications [247]. Semtech had 16 completed or assumed completed deals, out of which 7 were acquisitions, 3 were capital increases, 3 were minority stakes and 3 were share buybacks. Out of 7 acquisition, 6 were related to enhancing technology of specialized chips and IC and 1 related to a networking components (wafer bumping). Semtech's 3 capital increase deals were related to enhancing technology using specialized software and M2M / IOT communications. 3 minority stakes deals included a specialized software for fibre and radio networks and 2 shares sales by investors.

Orbcomm Inc.(Orbcomm), founded in 1985, is a commercial satellite wireless communication services company. Leveraging multiple satellite and cellular networks, Orbcomm offers industrial IoT and M2M communications solutions to monitor and control fixed and mobile assets in diverse sectors including transportation, heavy equipment, maritime,

oil and gas, utilities and government [248]. Orbcomm had 16 completed or assumed completed deals, out of which 10 were acquisitions, 4 were capital increases, 1 minority stake and 1 IPO. All 10 acquisitions were related to extending technology capability such as sensor enabled notification system (SENS), satellite and GSM data communication, wireless hardware and software for remote monitoring, business supply chain software and special emphasis on transportation monitoring enhancements. All 4 capital increase deals and 1 minority stake deal were related to financial instruments to raise capital.

#### 4.1.5.5 Links between PTC, Itron, Semtech and Orbcomm

There were no deals directly between any of the 4 hub firms of the cluster, namely, PTC, Itron, Semtech and Orbcomm. Orbcomm, Itron and Semtech were connected through a single firm called Millennium Management LLC, which is a large US global investment management firm. Millennium Management LLC was also an investor in Amazon.com Inc. Eagle Asset Management, a large diversified investment firm, was connected to both PTC and Semtech. UBS Asset Management Americas Inc., a US based global investment management firm, is connected to PTC, Itron and Semtech. UBS was also an investor in Amazon, Salesforce and Intel.

#### 4.4.3 Inter-Cluster Links between Hub firms

The hub firms across the clusters had no direct links with each other. Eight of the nine hub firms were found to be linked exclusively through investment banks and financial institutions (Figure 4-9). With the exception of 2 investment banks based in Norway and Canada linking Intel and Amazon, the others were all US based.

## 4.5 DISCUSSION

The deals analysis method has revealed 9 IOT linked hub firms in the five largest clusters with combined deals ranging from 98 to 512 in each cluster, as compared to other major firms well known to be associated with IOT. By contrast, Cisco Systems had eight deals, Google Inc. had two deals and Siemens AG had three deals. In addition, the hub firm KPN does not appear in industry rankings of top IOT firms. Crunchbase, a leading database for company insights

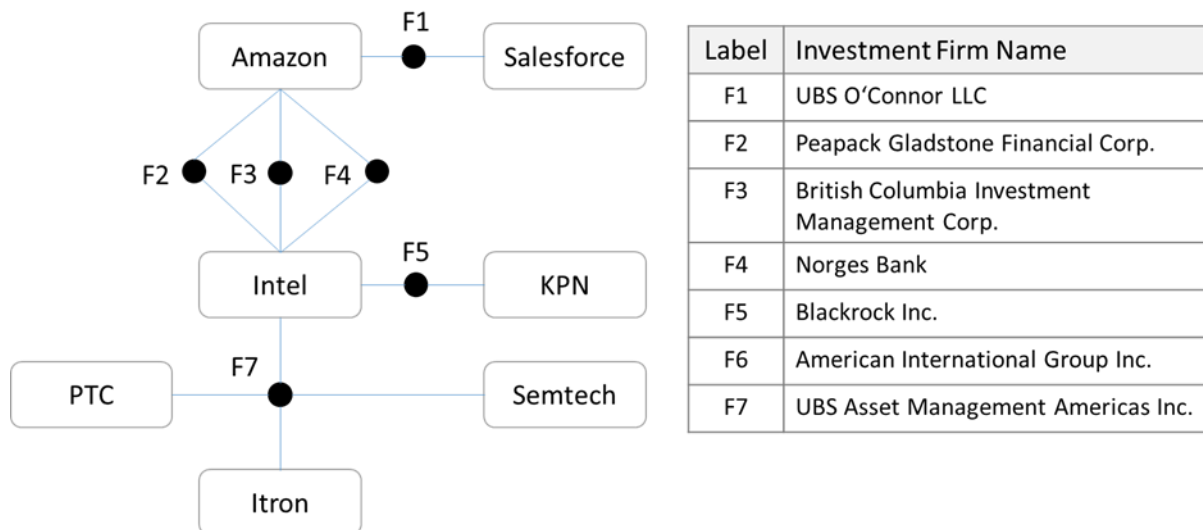


Figure 4-9 Inter-Cluster Links between Hub Firms

from early-stage startups to the Fortune 1000, does not classify KPN under their Internet of Things category [249].

Some investment firms were the sole links between multiple non-competing hub firms within the same cluster. These connecting investment firms were found to be US based and supporting US based firms, which could be an indication of affinity due to regional proximity and understanding of risks of investing in the same emerging industry. It can be further considered that certain innovative geo-locations possess allied services and learning spillovers that incentivize the risk appetite of investors [10]. Other hub firm investment strategies that are identified through the rationale of deals and associated industry news are listed below:

#### Market-Oriented Strategies:

- Growing global footprint in existing business e.g. multiple acquisition of telecom firms in home country and neighboring countries (KPN), large funds injections into Indian subsidiaries (Amazon)
- Expanding product portfolio range e.g. physical store for organic foods retail (Amazon), mobile heavy equipment and railroad industries data satellite monitoring (Orbcomm)
- Marketing to communities e.g. online social media marketing management (Salesforce), online booklovers community (Amazon)

- Facilitating sales e.g. shoe measurement comparison software (Amazon), regional online payments (Amazon), online e-mail and social media marketing software (Salesforce)

#### Technology-Seeking Strategies:

- Investments to enter new applications and services leveraging existing product and services portfolio e.g. refrigerated transportation monitoring (Orbcomm), wireless charging semiconductor (Semtech), online real-world photographic spaces 3D models software (PTC), online artificial intelligence (AI) platform (Salesforce)
- Enhancing customer experience e.g. all lighting conditions technology for Kindle and speech synthesis solutions (Amazon), graphics visualization technology (HTC)
- Adding efficiency to logistics & distribution operations e.g. shelving robots & autonomous carts (Amazon)

#### Market-Oriented or Technology-Seeking Strategies depending on the case:

- Advancing existing products and services e.g. specialized networking semiconductor chips (Intel), fabless semiconductor communications system on Chip (SoC) technology (Semtech), online cloud-based connected products and machine-to-machine applications platform (PTC)
- Leveraging corporate venture arms e.g. Alexa Fund (Amazon), Intel Capital Corporation (Intel)

Each hub firm engaged in multiple listed investment strategies with different intensity in terms of number of proportionate deals for each one. For a deeper assessment of such differences in strategies, we leverage the body of knowledge contained in the domain of alliances.

The motivation behind formation of alliances by firms in a network has been proposed as enhancing competitive positioning or market power, quest for knowledge, capabilities addition and reduced transaction costs [250]. In an emerging industry, startups with niche offerings, being relatively smaller than their rivals, tend to engage in alliances to gain economies of scale and scope [251]. Hub firms in order to survive or thrive in times of rapid technological change build capabilities through acquisitions or spinoffs that are later integrated [252].

To observe cumulative deal making tendencies of hub firms in market-oriented vs. technology-seeking inclinations, we applied a quantitative basis to the qualitative understanding of these inclinations from literature. Using the rationale of deals content in the Zephyr database fields “Deal Rationale” and “Deal Comments”, assessment criteria as described through examples in Table 4-7 were applied to categorize the deals inclinations into market-oriented, technology-seeking or other. Related corporate press releases and non-firm published news reports were referred to when clarifications and reinforcement for the assessments were necessary. In some cases, where the hub firm invested in a firm with similar end products, an assessment of novelty was applied to categorize novel product addition as technology-seeking. The notion of novelty was applied when the target firm was a startup and when more descriptive and differentiating vocabulary on the technology details were present. Market-oriented sales and marketing related deals included digital enablers such as online advertising, market trends, social media and community building. Novel technologies that resulted in superior digital user experience were categorized as technology-seeking. Certain supply chain components may be novel enough for the time of deal, however, due to the emerging industry being analyzed in this study, there is a higher likelihood that the inclination of at least a majority of such deals are technology-seeking. All supply chain components addition or enhancement were therefore categorized as technology-seeking as per the past literature definition.

The chart in Figure 4-10 has positioned the hub firms by their respective counts of market-oriented and technology-seeking, while excluding deals that involve shares purchase or sale by investors, subsidiaries and financial instruments for raising capital. The size of the bubbles representing the firm positions are proportional to the total number of market-oriented and technology-seeking deals in which they engaged. The total area of the chart is divided into quadrants to highlight simultaneously deal making propensity and choice between market and technology as the two exclusive parameters that are further analyzed. In Figure 4-11, proportion of market-oriented and technology-seeking deals of the hub firms are illustrated. Here, HTC is an outlier, as 207 out of 229 deals were related to sale of HTC shares by investors. In the market-oriented vs. technology-intensive inclination framework, Amazon and Intel are positioned in two extremes in quadrants II and IV respectively. Amazon’s IOT related deals reflected a more market-oriented deals strategy that benefits multiple ecosystems existing within its B2B and B2C businesses. As highlighted in Table 4-4 and Table A1, Amazon’s acquisitions, minority stakes and capital increase deals that are directly related to AWS or B2B

Table 4-7 Assessment criteria examples for categorizing deal inclinations

No.	Target Type	Product or Service Type	Example	Likely Inclination Category
1	Similar business category as acquiror hub firm	Common product existing in the market with acquiror hub firm others	Amazon.com's acquisition of Turkey-based online flower and gift retailer	Market-Oriented
2	Similar business category as acquiror hub firm	Common product existing in the market with acquiror hub firm others	Fabless semiconductor manufacturer in India acquired by Intel	Market-Oriented
3	Similar business category as acquiror hub firm	Enhanced product with novel* components or other novelty*	Intel's minority stake investment in UK start-up which claims a world lead in combining optics and electronics on a silicon chip	Technology-Seeking
4	Supply chain component	- all types -	Amazon.com's acquisition of Colorado-based warehouse robotics manufacturer	Technology-Seeking
5	Sales and marketing enhancer	Common product or service and technology enabler e.g. online advertising, market trends, social media and community building	Amazon.com's acquisition of Madrid-based private sales and exclusive membership online retailer	Market-Oriented
6	User experience	Novel* technology based enabler	Amazon's acquisition for Kindle eBook reader) of Samsung LCD Netherlands R&D Center BV that holds IP for screens that can handle "all lighting conditions" for mobile devices	Technology-Seeking
7	Subsidiary, shareholder or investor	Financial instruments, shares sale or purchase	n/a	Other
8	Different business category as acquiror hub firm at the time of the deal	Product or service not offered by the acquiror hub firm at the time of deal	Amazon's minority stake investment in India-based online consumer loans and insurance products rate quotes marketplace provider	Other / Not easily classified

\*The goal of a novel assessment is to determine its novelty for the time of the deal or application that was not common at the time. For this purpose, novelty is considered more likely when the target firm was a startup and when more descriptive words on the technology details were present (as compared to cases where the target firm was described more briefly with generic mention of its business function that matched the hub firm).

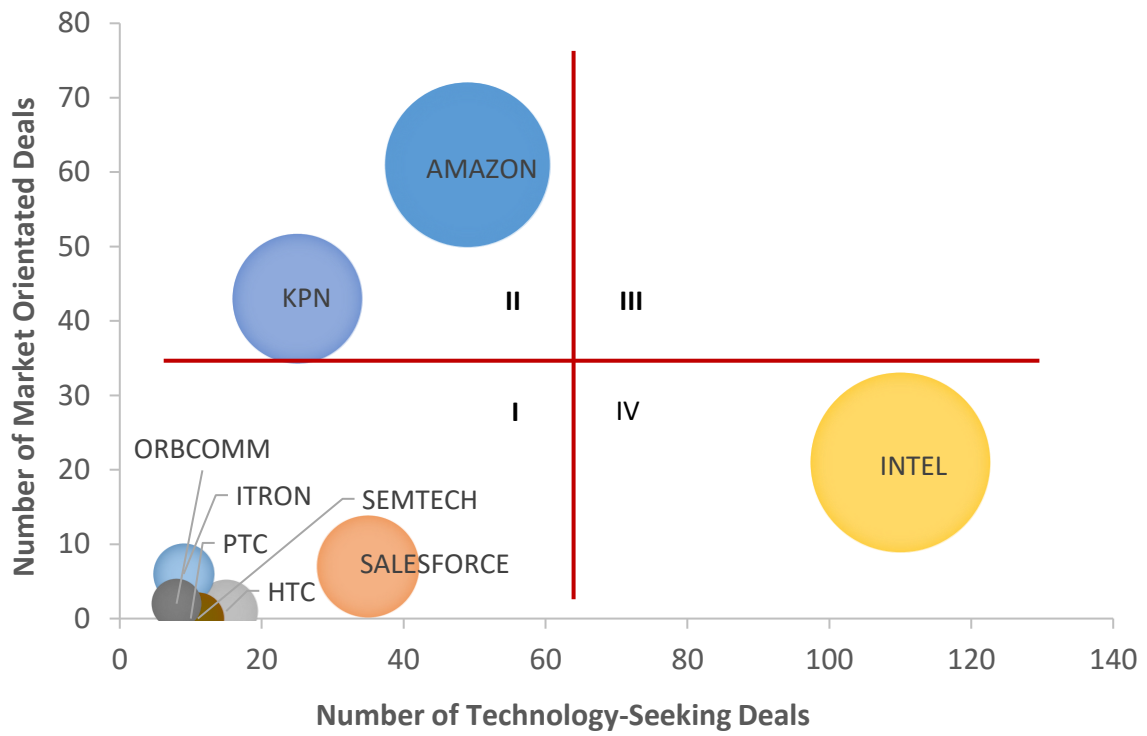


Figure 4-10 Hub firms positioning by Market-Oriented vs. Technology-Seeking Deals (Bubble size indicates the total number of both types deals)

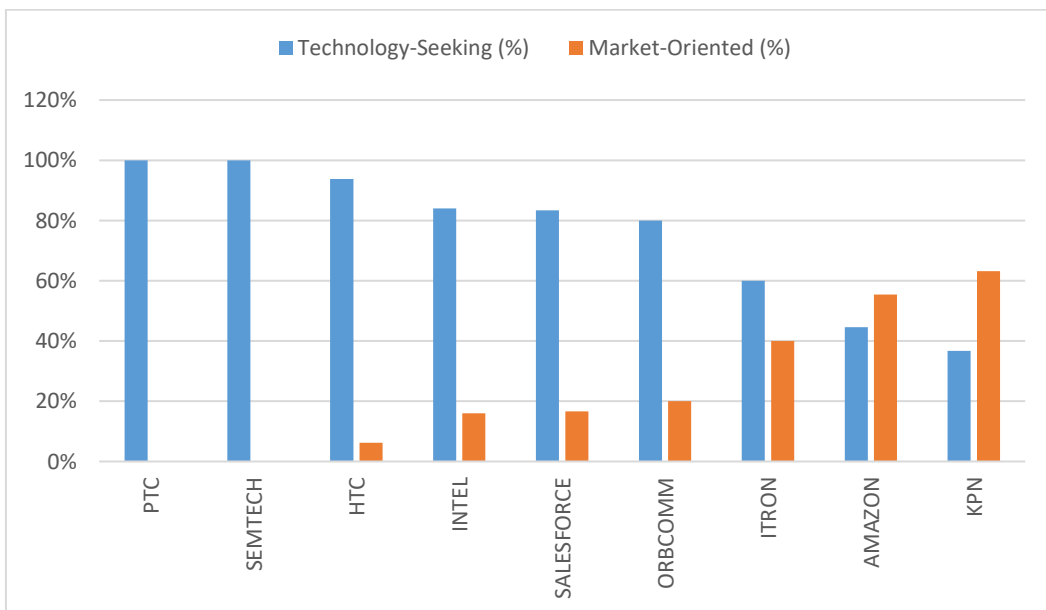


Figure 4-11 Proportion of Market-Oriented and Technology Seeking Deals in Hub firms

appear to be less than 10% of all its deals. It can therefore be inferred that Amazon's IOT related deals have been primarily related to its global retail B2C business. Inclinations of 55% of Amazon's deals were market-oriented, while 45% were technology-seeking, thereby suggesting a slightly higher market-oriented inclination of expanding portfolio of consumer products in regional markets. In contrast, Intel's core business of supplying semiconductor chips relies heavily on adapting to new technologies, devices, market applications and end user needs, making it fundamentally more reliant on technology advancing alliances. Similar to Intel, Salesforce, displayed an inclination of investing more in technology-seeking over market-orientation. This inclination suggests that Salesforce has chosen to lead advancements in CRM related services, rather than acquire market share by acquiring other CRM software firms. The tagging of Salesforce as an IOT firm reflects the proximity of CRM to edge devices for automation, analytics and AI applications. The cases of PTC, Itron, Semtech and Orbcomm are similar to Intel in terms of their dependence on launching more technologically advanced products, expanding services around their core product offerings and adapting to new technologies to stay relevant. However, due to their relatively smaller size and niche offerings, currently exist in smaller ecosystems (Quadrant I). KPN is positioned close to Amazon (Quadrant II) in the number of deals and preference for exploitative deals. KPN's business of growing telecom footprint can be envisioned as similar to Amazon's retail growth footprint, thereby justifying their exploitative strategy. Another aspect of importance for a hub firm is the ability to continuously absorb knowledge from explorative alliances and convert it to commercial offerings in a streamlined manner. Such an ability is derived from the firm's level of prior related knowledge, which is apparent in the large proportion of exploratory deals that are closely related to the hub firms existing portfolio.

A further validation of market-oriented vs. technology-seeking tendencies is obtained from a trend analysis of the deal types that the hub firms engaged in over time. Figure 4-12 plots cumulative deals by year from 2005 to 2019 that illustrates the consistent tendencies of the major hub firms. Amazon has maintained a slightly higher market-oriented inclination consistently from 2015 onwards, while it was more equally favoring technology-seeking deals around 2012. Intel has tended to slowly increasing its market-orientation. PTC, Semtech, Orbcomm and Itron are not displayed as their number of deals is relatively much smaller.

In summary, we posit that for the IOT space evaluated in this study, a relatively high volume of deals as compared to industry peers, with a high proportion of market-oriented vs.

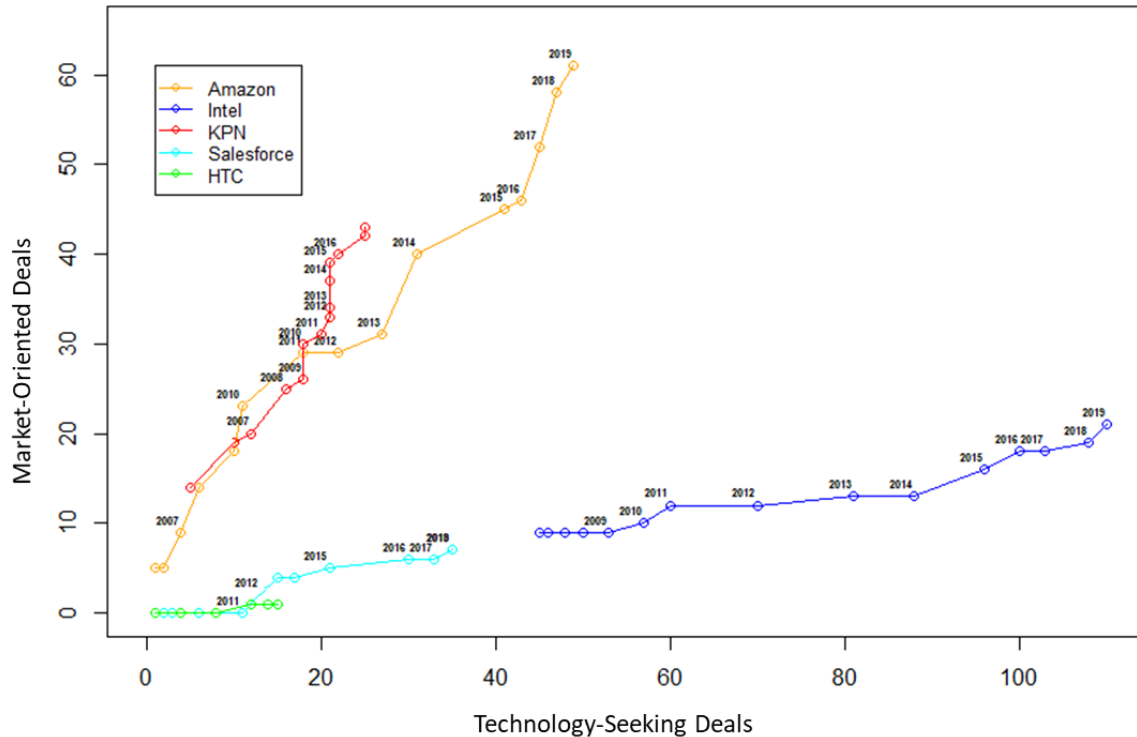


Figure 4-12 Cumulative Deals of Hub Firms, Year by Year from 2005 to 2019

(Each data point in ascending order is cumulative deals by market-oriented vs. technology-seeking tendency of firm starting for 2005 to 2019)

technology-seeking deals is an effective strategy. For knowledge intensive industries, a slightly higher proportion of technology-seeking deals as compared to market-oriented deals is desirable, and vice versa for businesses such as traditional retail and telecommunications services. Finally, adequate and timely funding is an essential ingredient for ecosystem growth and especially for the hub firms. For this ingredient, geographical co-location with complementary firms and emerging technology investor groups offers certain advantages.

The deals network analysis method used in this study uses subject-relevant deals and degrees of connectivity to identify larger clusters and their respective hub firms. While the number of deals is a good indicator of level of activity of the sector being analyzed such as IOT in this case, a high proportion of deals related to shares sale by investors, buybacks, financial injection into subsidiaries and financial instruments for raising capital can skew the results for ecosystemic insights. Deals between value chain firms, complementors, intermediaries and influencers are more valuable for an understanding of the structure of ecosystems. This limitation is observed for the hub firms HTC and KPN. Eliminating pure financial deals from the analysis may reveal new clusters, yet lesser overall financial activity may reduce the

prominence of certain clusters especially if such deals represent funds injected into firms that support growing their ecosystems.

The source of information used to classify deals as market-oriented vs. technology-seeking includes corporate press releases, news sources, websites of stock exchanges and firms. Each of these sources could contain bias, in terms of signalling an intention to customers, competitors and other stakeholders. The magnitude of the bias can be substantial if the firm's intention through a press release is to assess competitor and customer reaction before executing on the intention. While this aspect is a limitation for accurate interpretation, the fact that deals involve a financial transaction coupled with the communication, can serve to reduce this bias. In addition, the method to classify deals used in this study has attempted to reduce the bias through subjective approaches that are illustrated with examples in Table 4-7.

Classification of deal types as market-oriented and technology-seeking in digital context does not provide granularly for full contextual assessment in view of all parameters and variables. In a semantic sense, technology-seeking should account for novel technologies at the time of the deal and market-oriented inclination should consider use of technologies that are already in existence in other firms or applications. An example to illustrate this limitation is the business function of mobile payment. In 2013, Amazon acquired only the mobile payment technology of GoPago Inc., a San Francisco, California-based mobile payment software developer. At that time, Amazon already had in-app mobile payment system for apps sold via Amazon's app store and had launched "Log In and Pay with Amazon", a digital wallet service [213]. Today, Amazon offers Amazon Pay, a payment platform service for other businesses to integrate [253]. With the information available, it is hard to judge if GoPago Inc. technology was novel at the time or not. To further reinforce this example, in 2016, Amazon acquired Emvantage Payments Pvt. Ltd., an India-based online payments platform provider. An industry news article claims the rationale of this acquisition is to develop India specific payment solutions [214]. Amazon Pay was launched in India in 2017, while the incumbent PayTM launched in 2010 is still the mobile wallets market leader [254]. It is therefore difficult to precisely assess the novelty of Amazon's mobile payment technology acquisitions. Another example is Intel's acquisitions of 19 specialized chips and IC manufacturers and 14 specialized software developers that are hard to discern for novelty. Moreover, the bibliometric methods used in this study are suitable for identifying macro trends from deals databases and likely to miss certain micro trends that could be relevant for insights into firm strategy.

Deriving firm strategy insights from hub firms of large clusters of a deals network is one of several constructs for an understanding of ecosystem firm strategy. In-house applied R&D priorities declared publicly or through patents activity can supplement the objective. R&D capability when extended beyond just new technology to domains such as applications, markets, sales tactics, customer and competitive intelligence, etc. can be acquired through hiring key personnel and setting organizational priorities. Several well-known innovative firms leveraging IOT technologies were not revealed through the deals analysis possibly due to this construct of internal competence development. Another construct that contains related strategy information not easily revealed by deals, is a firm's investment in own subsidiaries and previously established partnership such as dealers networks, either in different businesses or regions. News sources on competitor reactions can provide likely rationale for such moves. Information sourced from databases tracking venture capital and startups activity such as Crunchbase [255], can offer an additional source for triangulation of information for added comprehensiveness on firm strategy insights. In spite of the short time span of the IOT related deals from 1993, a temporal analysis coupled with the state of the art of the industry at each period can reveal firm strategy in terms of deals influenced by competitive reactions, innovation culture, regional demands, available technology infrastructure and readiness of complementary actors, targeted early mover or fast follower advantage seekers and other strategies. Finally, analyzing cross-industry high deal making firms through the explorative-exploitative lens, can offer a deeper industry agnostic understanding of effective deals portfolio.

The guidance for ecosystem firm strategy is multifold. Firms that seek a hub or central role in an ecosystem, as a strategy are likely to benefit from routinely engaging in high number of deals for access to valuable product and competitive knowledge. Firms that seek to engage with an emerging ecosystem, should evaluate the hub firm by their deals activity. The high number of deals of the hub firms should comprise largely of explorative and exploitative deals, while their relative proportion in the portfolio mix would depend on their core business function. For rapidly evolving technology intensive ecosystem, a higher proportion of explorative deals may offer a longer term benefit. Policy makers seeking to encourage an emerging industry can be guided by the findings on hub firm investment strategy, and identify approaches to incentivize them for the desired mix of deal making. The incentives to evaluate may include reduced taxes and duties, subsidies, ease of transacting, access to establish operations in locations that contain

investor communities of similar industries, allied services and markets, as appropriate on a case-by-case basis.

#### **4.6 SUMMARY**

Firms linked to IOT that occupy a hub position of the largest clusters in a network of deals were identified in this study. Among the top 5 clusters, 2 clusters contained more than one hub firm and were connected to each other solely through investment firms. The common investors were found to be mostly US based firms and their investments were for US based hub firms, suggesting a regional industry affinity. 9 hub firms of the selected top 5 clusters were further profiled by the rationales of their deals. These firms were Amazon, Salesforce, HTC, Intel, KPN, PTC, Itron, Semtech and Orbcomm. KPN, a major Dutch landline and mobile telecommunications firm was found to be an outlier, as it is not generally tagged as an IOT firm by common industry sources. HTC was also found to be an outlier in the list, as 95% of its deals captured its decline through shares sales by its investors.

## **5. DISCUSSION AND CONCLUSION**

The findings in this research have highlighted the value of an improved firm engagement search with less visible ecosystems and entities within them. Through the lens of a business ecosystem (BE), a firm can gain competitive advantage through access of niche knowledge, technologies and enter alliances for implementation with both firm and non-firm entities of other business ecosystems as well as innovation ecosystems (IE) and digital ecosystems (DE). This engagement search as a strategy is supported with derivations from strategies utilized historically for deals that contributed to formation of the contrasting EV and IOT linked global ecosystems. The firms studied have varied in business function, size, products and services diversification, niche offerings, presence of complementaries, infrastructure maturity, financial strength, position in the value chain, status of ecosystems engagement, deals activity, regional incentives and various combinations of these parameters. Towards the goal of combining the learnings for a unified directional guidance, firms with certain combinations of these parameters are profiled for effective strategy making.

### **5.1 ACCESSING LESS OBVIOUS NICHE KNOWLEDGE**

Alliances with firms, non-firm entities and existing innovation ecosystems with less obvious cross-knowledge sharing can offer additional information for effective future strategy decision making. Illustrative examples in Section 2.4.2 such as for smart cities, trust-agent and helix types have highlighted the knowledge from cross domains that could be business critical to leverage for niche offerings. The ability to institutionalize such thinking has a dependence on the prevailing firm culture and leadership. The inter-relationships between BE, IE and DE as illustrated in Figure 2-61 offers an expanded view of outreach to potential firm and non-firm members for an ecosystem or linking to existing ecosystems. IE focused on science, technology and policy could be a rich source of knowledge from non-firm entities such as universities and municipalities, while DE could contain existing digital systems and components that serve as a ready implementation arm.

### **5.2 FIRM ENGAGEMENT PATHWAYS**

Four types of generic firms A, B, C and D are perceptually mapped in the market-oriented vs. technology-seeking inclination framework as proposed earlier in Figure 4-10. The pathways

for growing of these generic firms through intentional engagement with specific types of ecosystem firms or equivalent internally developed capabilities is proposed with arrows in Figure 5-1.

Firm A is a representation of very large diversified firms that are primarily end consumer facing. The notion of a threshold of market-orientation tendency as guided by literature is suggested, wherein a Firm A on achieving a near monopolistic status may find it beneficial to engage in more knowledge or technology-seeking initiatives. Amazon for example, may now choose to increase its own retail product offerings, add products of others to fill gaps as a one-stop shop and include more value added services to say Kindle, Alexa and AWS product lines to increase its earnings per subscriber as compared to continued efforts to increase its subscriber base.

Firm B represents large incumbent firms with less diversified product portfolios in a technology intensive business; such firms are likely to be specialized component suppliers such as Intel. Intel can be considered diversified within the semiconductor manufacturing sector as a dominant firm with a wide spread of applications leveraged by technology-seeking deals in networking, communications and integrated systems such systems on a chip. However, as illustrated in Figure 4-10, there is possibly an opportunity for Intel to benefit from engaging in more market-oriented deals. Intel is viewed today as the second largest global semiconductor chips supplier with Samsung overtaking it as the first. Intel also faces stiff competition from AMD, Nvidia, Qualcomm, IBM and Asus [256]. Intel's market share erosion is attributed to less focus on smartphone related chips [256, p. 6], which brings about the point on focus on type of exploratory deals. The nature of exploratory deals aspect is outside the scope of this study, but at the same time this aspect suggests a consideration into the nexus between market-oriented and technology-seeking deals. Market-oriented deals by Intel, could more clearly focus on entry into the smart devices sector and other upcoming sectors. Intel's recent foray into chips for autonomous cars [257] can be interpreted as technology enhancement inclination. Another aspect highlighted by the case of Intel when compared to Amazon where they have been positioned in extreme quadrants in Figure 4-10, is the difference in the nature of their business functions. Intel is predominantly a component supplier while the IOT linked deals of Amazon were related to end consumer facing with online retail.

Firm C and D are small to medium firms in less and more knowledge intensive businesses respectively. While knowledge is a necessary ingredient in any business, a less knowledge intensive business in the case described here would be a less novel product offering such as

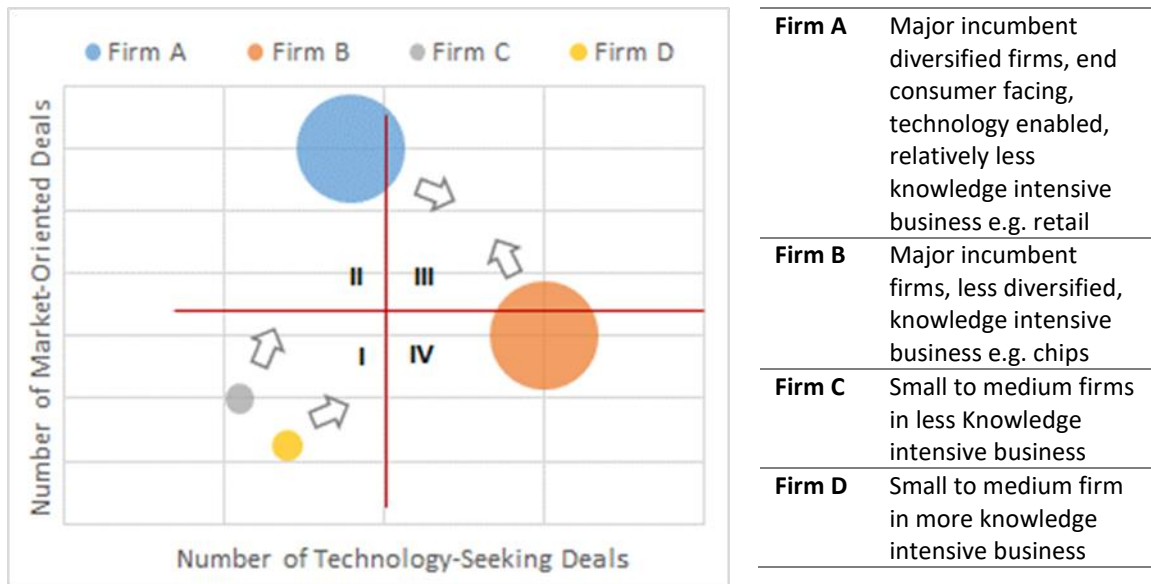


Figure 5-1 Perceptual positioning of firm types by deal inclinations  
 (Bubble size indicates the total number of both deal inclination types)

flowers retail. This is a relevant case in context of this study, as Amazon has invested a minority stake in a Turkey-based online flower and gift retailer. A profile as Firm C would seek to align with a larger exploitative Firm A. Firm D firms include ones that leverage novel technology and their applications as found in several niche start-ups and small to medium sized incumbents such as PTC, Itron, Semtech and Orbcomm. Firm D firms are challenged to stay relevant by adoption of innovations that leverage upcoming technological advances and supporting infrastructure, and therefore need to lean a bit more towards explorative inclination.

### 5.3 HUB FIRM ASPIRATIONS

The findings from the EV ecosystems have provided evidence that incumbent firms from various original positions of the value chain can stimulate the formation of an ecosystem. A prominent example is the case of ZTT, whose primary business function is manufacture of power transmission and optical fibre cables i.e. a core infrastructure component for EV charging, that expanded its component portfolio through deals to acquire capability for manufacture of Li-ion battery and PV panels. Other strategies employed by EV firms that achieved a hub position are upstream and downstream integration, diversification motivated by technological threats and new market entry. Among the EV hub firms, BYD has demonstrated the highest inclination for upstream and downstream integration and emerging as a leading EV

OEM. This positioning places BYD in a possible platform leadership or ecosystem keystone. BYD can engage further by including downstream services to vehicle drivers and maintenance service providers to govern ecosystems that it controls and orchestrate its members as a focal firm. While deals based hub firms are not necessarily focal in the value chain of an ecosystem such as a vehicle OEM in case of EV, they can be a major beneficiary of the evolving ecosystem that could be governed by other firms. At any stage of maturity of the ecosystem, accelerating enrolment of members to the ecosystem that address co-innovation and co-adoption risks would be an indicator of ecosystem health that benefits and sustains all members [38] [26].

In addition to the business function agnostic nature of hub firms of ecosystems, the notion that Firm types A, B, C and D as defined in Figure 5-1 can be members of the same ecosystem is suggested. Firm C could open a new regional market and Firm D could offer a niche service, while either case can be receive ecosystem support from Firm A and B as suppliers to the value chain.

#### **5.4 ALIGNING WITH REGIONAL INNOVATIVE CLUSTERS**

This study have identified evidence from both the EV and IOT case study that there exist regional influences that promote innovation. The EV case study has highlighted governmental incentives in China, Taiwan and Republic of Korea, technology push in US and born global cum future outlook culture in parts of EU. This condition requires supporting infrastructure and availability of complementary services. The common US based investment banks for the US based IOT hub firms suggest an understanding and comfort with financial risks-rewards for certain emerging industries and firm culture. Within the political boundaries of countries, there exist areas which are more conducive to formation of ecosystems. In addition to ease of access to funds in such areas, availability of complementary services and resources to rapidly scale up are critical factors [10].

#### **5.5 LIMITATIONS**

Firm strategy literature is extensive, ranging from competition, markets, product portfolios, organization design and leadership, and diverse topics within each and their combinations. The broad literature base also contains valuable insights from a business ecosystem perspective as well. This research has identified such insights in the EV case study as enumerated in the EV case study such as upstream and downstream integration. Regional

incentives and symbiotic clusters highlighted in this research are also well known enablers. While this research has validated and identified certain specific strategies applicable for business ecosystems, it is somewhat limited in its breadth and depth coverage for general guidance. Leadership aspects that influence business risk appetite that may result in desirable market outcomes including motivation for other actors to enrol irrespective of the region or even the type of emerging industry has not been addressed. Firms seeking a hub position by expanding their control over a larger part of the value chain has several possible permutations that require evaluation metrics, which were outside the scope of this study. The strategy derivations based solely on deals with external firms is incomplete as a general guidance without considering aspects on internal investment strategies.

## **5.6 FUTURE DIRECTIONS**

The search for relevant and less obvious knowledge can be critical for firms engaged in offering emerging products and services to gain a competitive edge. In this study, the value of integration of IE and DE with BE for this purpose is highlighted. With the rapidly growing scientific advances globally and with potentially cross-sector applications, firms need an efficient method for such awareness. The programmatic approach suggested in this study using keywords network analysis can be expanded towards this goal. Engaging with IE offers the opportunity to have access to bridging resources as well to compensate for the firm's absorptive capacity. Engaging with DE can offer niche digital application tools and methods from the start-ups community.

The ecosystem firm strategy possibilities suggested in this study would gain from further strengthening with more empirical evidence. Validation of the firm engagement pathways can be attempted through deals analysis in other emerging sectors as well as alternate approaches that reinforce a success metric on following the pathway for firm type. The latter could leverage financial data and share prices trends correlated with strategy decisions. More case studies of small to medium firms, especially start-ups that formed ecosystems by leveraging larger incumbent firms would offer an understanding of deeper facets of business function and value chain position agnostic hub firm suggested in this study. Measureable influence of non-firm entities that traditionally reside in innovation ecosystems (IE) is another less explored area in literature. Finally, cross-knowledge access that could offer a substantial competitive edge requires more method research to cover a wider range of topics.

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## 7. APPENDICES

List A1. Redundant, abbreviated and common ecosystem related vocabulary eliminated from the study

business ecosystem, digital ecosystem, innovation, innovation ecosystem, knowledge, management, ecosystem, industry, model, business, challenge, science, information, role model, design, impact, future, relevance, accountability, architecture, choice, constructing, history, market, mof, regional innovation, product, regions, aal, bottom, brand business ecosystem, business ecosystem niche, coap, costs, directions, era.

Table A1 Amazon.com Minority Stake & Capital Increase Deals

<b>Business Functions of Amazon's Minority Stake Deals Firms</b>	<b>Country</b>	<b>Deals</b>
Online vehicles general insurance provider	India	2
Online daily discounts and coupons portal operator	USA	2
Online advertising forecasting, analytic pricing and trading platform	USA	2
Automatic video editing technology platform operator	USA	2
Online music retailer	USA	2
Automatically-generated video production software developer	USA	2
Online-based information sharing platform operator	USA	2
Cloud storage solutions developer	USA	2
Online cloud-based orchestration platform operator	USA	2
Online handcrafted products retailer; Internet payment technology developer; Self-driven car software developer; Online advertising publishers and marketing services; Online food related videos creation & sharing mobile platform operator; Online booklovers community operator; Online media management platform operator; Online cloud-based API telephone communications platform operator; Online music streaming platform operator; Online cloud-based data storage, archiving and search platform operator; Online open source content management & web dev. platform operator; Application management software developer; Data processing services; Enterprise analytics online platform operator; Cooking website operator; Smart wireless router manufacturer; Online fashion magazines publisher; Fantasy game site developer; PDF document management software developer*	USA	19 (1 each)
Online on-demand home services marketplace operator; Mobile payment solutions provider; Business process outsourcing (BPO) services; Online consumer loans & insurance products marketplace provider; Mobile-based location management platform provider*	India	5 (1 each)
Online website text-to-audio solution platform operator	Brazil	1
Home climate control smart thermostat manufacturer	Germany	1
Social network application developer	Israel	1

<b>Business Functions of Amazon’s Minority Stake Deals Firms</b>	<b>Country</b>	<b>Deals</b>
Courier services	France	1
Online restaurant food ordering and delivery platform operator	UK	1
Online flower and gift retailer	Turkey	1
Online fresh produce and groceries platform operator*	China	1
Robotic control equipment manufacturer*	Japan	1
<b>TOTAL</b>		<b>50</b>

\*These business functions are classified in Zephyr as “capital increase” deals, while the others in the list as “minority stake” deals.