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Growing Pains of Industrial Renewal

Case Nordic Cleantech

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Growing Pains of Industrial Renewal – Case Nordic Cleantech

Abstract

To steer economies onto a sustainable path in a way that is compatible with the urgent priorities of economic developers, sustainability needs to come with new business opportunities, growing markets and, most importantly, new jobs. The big question becomes then how do you wed economic growth with sustainability? Enter the growth of cleantech and the emergence of green industries. Recent rankings place Finland in the top-3 of global leaders in cleantech, along with Israel and the US. Driven by an ambition to selectively invest in a 'green' economic turnaround, a number of strategy-level research documents and roadmaps have been produced in recent years on how to kindle new growth and create jobs in the Finnish CleanTech- and the Bio-economies. The three industry ecosystems frequently mentioned are efficient energy solutions (smart grid), mobility-as-a-service (smart mobility), and the bioeconomy. The ultimate questions to be answered are: In which industry ecosystems does Finland have the necessary assets to be an effective competitive contender? And given the existing asset base, what is the true potential of these sectors as engines of economic growth?

To rise to the challenge, the report probes (a) the structure and direction of industrial activity that underlie the selected ecosystems, (b) the value capture potential of individual companies in them, and (c) the types of financing the companies are most compatible with.

The results are somewhat sobering. They clearly show that for business and economic development purposes the only feasible approach to Cleantech is to deal with it by the ecosystem. The three ecosystems analyzed in this study all feature different industrial structures, make vastly different value propositions, address different markets and involve a very different set of stakeholders. There is little value in cursorily lumping them together under a quasi-common concept such as Cleantech or the Bioeconomy. These concepts have no substance as they do not refer to specific industrial or economic activity. Hence, it is also very challenging to develop concrete instruments for economic or business development purposes that are to promote such activity. At worst, scarce resources are put to suboptimal use, as they are allocated over a vast spread of individual companies and projects that might be a fit with the overall theme of Cleantech but have no common denominator in the form of an industrial ecosystem and its underlying value chains. Our results on a next to non-existent Bioeconomy provide for an excellent showcase.

We further show that even the more promising ecosystems such as Smart Mobility and Smart Grids are in the throes of growing pains. There is much that economic developers can do efficiently to alleviate them. The poor leverageability of industry assets and connections for market access across the board speak of fragile, budding industry structures that make it difficult for companies to establish robust markets and steady businesses in the short term. Companies of different sizes suffer the symptoms in their own ways. On the one hand, large incumbents do wield the assets necessary to conquer the ecosystem – telecommunications operators seem to have an especially favorable vantage point in smart ecosystems – but shoot themselves in the foot by applying conventional, capital-intensive business models that leave the door open for more agile growth companies that harness the potential of digitalization to exploit opportunities. On the other, start-ups and SMEs indeed show the drive and lean on nimble enough business models but utterly lack the assets for a full-scale conquest.

It is easy to envision a symbiotic relationship, in which incumbents provide the capital-intensive assets while their smaller peers introduce the competitive business models. Given the incipient structure of the ecosystems, however, just finding appropriate partners can incur considerable transaction costs. Here economic developers can step in, helping to find matches via collaborative accelerators that broker partnerships between industrial heavy-hitters on a mission of industrial renewal and small growth companies looking for resources and downstream assets.

Finding partners is a formidable challenge in and by itself, but our conclusions point to even more systemic impediments to industrial renewal that lie outside the industry's sphere of influence. One such is the lack of proper standards for the interconnectivity and interoperability of the various, often proprietary, IT systems that the numerous stakeholders to ecosystems run their businesses on. Especially smart ecosystems by definition build on the seamless interoperability across diverse system architectures and organizational boundaries. In the absence of universal standards, interconnectivity needs to be established one relationship at a time, building on contractually agreed, customized solutions that do not scale beyond the specific relationship. Economic developers can considerably speed up the construction of a digital business environment by introducing universal standards that promote the emergence of plug-and-play platforms for efficient interoperability. In a world of autonomous, self-driving vehicles and applications that affect offtake and feed into electricity grids, quality and safety controls for algorithms that govern these systems will be paramount for individual and societal safety.

Key words: Cleantech, value capture, industrial renewal, industrial ecosystem, investability, sustainable growth, smart grid, smart mobility, bioeconomy

JEL: O11, O14, O25, O33, O38, O41, O44

Kivulias kasvutarina – Cleantech teollisen uudistumisen keskiössä

Tiivistelmä

Kestävän kehityksen syvin paradoksi piilee käsityksessä, että taloudellisen kasvun vaatimien panosten hankinta ja käyttö sotivat ekologisen ja sosiaalisen kestävyyden tavoitteita vastaan. Samalla kun maailman yskivään talouteen etsitään kipeästi keinoja markkinoiden ja työllisyyden kasvun kiihdyttämiseksi on esitetty argumentteja, joiden mukaan tapa, jolla käytämme luonnonvaroja taloudellisissa toimissamme, näännyttää kotiplaneettamme voimavaroja hälytyttävässä tahdissa jo nyt. Miten siis naittaa taloudellisen kasvun ja kestävän kehityksen tavoitteet keskenään?

Cleantech on käsitteenä yksi eniten palstatilaa saanut ratkaisukonsepti, jonka mukaan itse kestävien ratkaisujen kehittämisessä ja kaupallistamisessa piilee taloudellista kasvupotentiaalia. Uusimmat arviot asettavat Suomen kilpailukyvyn cleantech-alueella maailman parhaimman kolmen maan joukkoon Yhdysvaltojen ja Israelin rinnalle. Cleantech-ratkaisut on nostettu hallitusohjelmaan uusien työpaikkojen ja talouden kehityssuunnan kääntämisen toivossa. Usein mainittuja cleantech-ekosysteemejä ovat älyverkot (smart grid), älykäs liikenne (smart mobility) ja biotalous (bioeconomy). Suomen cleantech-ekosysteemien potentiaalin selvittämiseksi on kuitenkin tärkeää selvittää, missä niistä Suomella on rakenteellinen ja resurssipohjainen kilpailuetu kasvun alustamiskesi ja kuinka suuri itse potentiaali loppujen lopuksi on.

Raportti tarttuu haasteeseen ja luotaa (a) yllä mainittujen ekosysteemien rakenteita ja kehityssuuntia, (b) niissä toimivien yritysten arvonkaappauskyvykkyyksiä, ja (c) yritysten sijoituskelpoisuutta erityyppisten rahoitusvaihtoehtojen valossa.

Tulokset antavat aihetta keskustelulle. Ensinnäkin eri cleantech-ekosysteemien sisäiset teollisuusrakenteet eroavat toisistaan merkittävästi. Siinä missä molemmat älyratkaisujen ympärille rakentuneet ekosysteemit osoittavat vahvoja poikkiteollisia arvoketjurakenteita, ei biotalouden rakenteista löydetty juuri minkäänlaisia todisteita. Biotaloudesta ei ole odotettavista suomalaisen talouden veturia ainakaan lyhyellä aikavälillä.

Myös molemmat älyekosysteemit kärsivät vielä kasvukivuista. Olemassa olevat resurssit eivät vielä sovellu suoraan tehokkaiden markkinakanavien luontiin. Tämä saattaa suureksi osaksi johtua myös markkinoiden hyvin varhaisesta kypsyysasteesta. On vaikea vallata heiveröisiä, kehittymättömiä markkinoita. Erikokoiset ja ikäiset yritykset kärsivät oireista eri tavalla. Erityisesti suurilla ja etabloituneilla yrityksillä on oikeanlainen resurssipohja nousevien ekosysteemien valloitukseen – erityisesti telekommunikaatioala näyttäisi olevan erinomaisesti asemoitunut hyödyntääkseen kasvun tuomia mahdollisuuksia. Suuryritykset kuitenkin ampuvat itseään jalkaan yrittämällä soveltaa perinteisiä, skaalautumattomia ja pääomaintensiivisiä liiketoimintamalleja uudessa kontekstissa. Tämä jättää oven auki pienille, ketterille kilpailijoille, jotka tarttuvat tilaisuuteen uudenaikaisia, digitalisaation tuomia ratkaisuja soveltamalla. Nämä nuoret ja pienet kasvuyritykset puolestaan kaipaavat kipeästi resursseja ja verkostoja täysimittaisen valloituksen toteuttamiseksi.

Suuret ja pienet hyötyisivät siis vahvasta yhteistyöstä, jossa suuryritykset avaisivat verkostonsa ja markkinakanavansa pienille kumppaneilleen ja pienet puolestaan päivittäisivät suurten kumppaniensa liiketoimintastrategioita vastaamaan nykypäivän dynamiikkaa. Kumppanuuksien löytäminen ei kuitenkaan ole helppoa eikä halpaa. Tässä yhteydessä yhteiskunnallisia panoksia voisi tehokkaasti hyödyntää partneroitumiseen erikoistuneen kiihdyttämötoiminnan kautta. Esimerkiksi Nordic Innovation Accelerator (NIA) on menestyksekkäästi auttanut suuryrityksiä niin kotimaassa kuin ulkomailla löytämään toimintansa kehittämiseen soveltuvia kasvuyrityksiä, jotka ovat sittemmin yhdistäneet voimansa uudenlaisten liiketoimintojen kehittämiseksi.

Toinen merkittävä hidaste erityisesti älykkäiden ekosysteemien kasvulle on tietojärjestelmien yhteensopivuuden ja siihen liittyen järjestelmien välisten viestintästandardien puute. Tällä hetkellä yhteensopivuudet eri toimijoiden välillä joudutaan ratkomaan tehottomasti yksi sopimus ja konsortio kerrallaan. Tämä ei vastaa modernin alustatalouden periaatetta, jonka mukaan toimijoiden rajapinnat ovat lähtökohtaisesti auki niin, että kuka tahansa osapuoli voi vapaasti tuottaa yhteensopivia ratkaisuja alustoille. Tässä kohdassa yhteiskunta voi vaikuttaa suotuisten, tehokkaiden puitteiden luontiin laaja-alaisen standardoinnin kautta niin kuin monella perinteisemmällä alalla on toimittu.

Asiasanat: Cleantech, puhtaat ratkaisut, arvonkaappaus, sijoitettavuus, teollinen uudistuminen, teollinen ekosysteemi, kestävä kasvu, älyverkot, älyliikenne, biotalous

JEL: O11, O14, O25, O33, O38, O41, O44

1 Introduction – Much Ado About Nothing or True Economic Momentum?

1.1 Economic and environmental issues compete for political attention

Global warming, urbanization, pollution, consumption, and the depletion of non-renewable natural resources; those are just a sample of megatrends that go hand in hand with policies for economic growth and well-being around the globe.

Many say our current ways are unsustainable, that it might already be too late to change course. With the brooding menace of ecological and, consequently, socio-economic catastrophe looming on the horizon, it is understandable that the demands and initiatives for aligning environmental and economic growth have intensified manifold in the past decade. Germany's Energiewende is one of the most high-profile examples of political initiative towards a more sustainable paradigm. The breakthrough Paris Agreement signed at the UN Conference on Climate Change in late 2015 is another, even if national ratifications on its execution are mired in uncertainty.

As a counterforce to the momentum, however, the global economy is in the throes of widespread political and economic convulsions. Europe is struggling with its lackluster competitiveness and effects on unemployment and growth. China has lost its momentum as a global growth driver, impacting commodities and trade. Cheap oil has made life for oil producing economies a nightmare, and has a disproportionate impact on stock volatility and corporate credit risk. The ripple effects of these events have impacted corporate value chains and global trade networks. As a result, these events have exposed both systemic and idiosyncratic (uncorrelated to the broader market) risks in the financial and real economies.

1.2 Investing in sustainability offers promise of reconciliation

To steer economies onto a sustainable path in a way that is compatible with the urgent priorities of economic developers, sustainability needs to come with new business opportunities, growing markets and, most importantly, new jobs. The big question becomes then how do you wed economic growth with sustainability? Enter the growth of Cleantech and the emergence of green industries.

Only as recently as 2008 did the Economist proclaim the "downturn of clean technology" under the "gathering clouds" of the global economic slowdown (Economist, 2008). Today, Chrysalix EVC, one of the longest standing venture capital firms in the cleantech space, estimates that the total addressable market for resource efficient technologies and services will grow to a size anywhere between three and four trillion USD by 2020 (van Lierop, 2014). This represents an eight-fold increase since 2005.

Cleantech has made a respectable comeback onto the global agenda of firms, investors and economic developers alike. In the past decade, this policy mandate and investment domain of leading venture capitalists in search for profitable business models has evolved into an economic megatrend with considerable industrial and financial momentum. Cleantech has gone mainstream. Its principles of resource efficiency coupled with enhanced financial returns have become integrated in nearly every sector of the economy.

With emerging industry ecosystems such as smart grid, smart mobility, and smart water showing promise of growing business potential, economic growth and ecological sustainability are co-evolving. Companies across a multitude of conventional industries – from Cisco to Siemens and Apple - are now investing in efficiencies and value added services. In the process, Cleantech business models are changing, allowing for scale and revenue growth. Enabled by intelligent integration of sensors, data, software, analytics, and financing instruments, the physical layer of Cleantech is becoming connected with the cloud. Cleantech is now part of the Internet of Things (IoT), characterized by intelligent goods and services.

1.3 Political agendas disregard de facto industrial momentum

In this evolution, the emerging industry ecosystems are by no means dominated by new players only. On the contrary, most of the emerging resource efficient applications are built on top of legacy infrastructure of incumbent industrial heavy-hitters. Energy utilities, telecommunications operators, electronics manufacturers and software houses are all crucial infrastructure cornerstones aiming to reposition their capital-intensive assets to take advantage of the new opportunities in a capital- and resource-efficient economy.

New, innovative ventures attempt to enter these value chains via supply chain relationships. Financed through the debt and equity markets, these firms seek to scale value-added products and services by unbundling assets and infrastructure of incumbent companies, according to CB Insights, a venture capital database. In doing so, growth companies with data- and service-driven business models impact and shape new markets. In essence, they drive the emergence of resource-efficient ecosystems and position themselves as the next growth centers of the economy.

In the global race for leadership in sustainable industrial renewal, it then becomes decisive whether an economy can leverage scalable legacy assets to drive those emerging industry ecosystems that the economy aims to compete in. Many times, policy-makers indiscriminately promote all and everything related to an emerging megatrend. What is often missed is that the country or economic region needs to differentiate and sustain its unique competitive edge to scale these economies, attract foreign direct investment (FDI) and grow into an export market. One cannot expect to win the battle by being non-selective.

In accordance with the notions of comparative advantage (Ricardo, 1817) and smart specialization (McCann and Ortega-Argilés, 2015), it is absolutely crucial to identify those industry subsectors – or better, ecosystems – that can leverage the assets of an economy. Building out entirely new industrial infrastructure systems from the bottom up – as opposed to leveraging existing strengths to grow a tax base and jobs in emerging cleantech ecosystems – is an extremely slow and capital-intensive proposition that rarely results in the intended short-to-medium-term economic growth.

1.4 As a leading cleantech economy, Finland seeks to develop a competitive and sustainable advantage

Recent rankings place Finland in the top-3 of global leaders in cleantech, along with Israel and the US (WWF & Cleantech Group 2014). Driven by an ambition to selectively invest in a 'green' economic turnaround, a number of strategy-level research documents and roadmaps have been produced in recent years on how to kindle new growth and create jobs in the Finnish CleanTech- and the Bio-economies (Sitra, 2011; TEM, 2014a,b). The three industry ecosystems frequently mentioned are efficient energy solutions (*smart grid*), mobility-as-a-service (*smart mobility*), and the *bioeconomy*. The latter is a broad concept for sustainable solutions exploiting the country's assets in biomass production, agriculture and opportunities in circulating excess materials between industrial sectors (*circular economy*).

The ultimate question to be answered is: In which industry ecosystems does Finland have the necessary assets to be an effective competitive contender? And given the existing asset base, what is the true potential of these sectors as engines of economic growth?

> By way of validating whether the political foci are justifiable in light of the stocks and flows in the real Finnish economy, we aim to generate novel insights that support the design of strategic policy roadmaps for economic development purposes.

By definition, roadmaps chart a path into the future. Therefore, generating valid insights requires going beyond observing the static assets of the Finnish (cleantech) economy. If policies are to impact investment and export opportunities, we need to pay attention to how the structure of the economy is evolving. It is important to discover whether there is true industrial momentum that is aligned with the political strategic aspirations for growth and renewal.

It is equally important to understand what types of monetary inputs are most effective in promoting the growth of various types of companies in these emerging cross-sector industry value systems. While scalable growth companies are attractive to traditional risk capital, others require more creative capital inputs, such as risk debt, minority equity or grant financing.

Informed by the discussions above, our approach is guided by the following questions:

1. Is the selection of industry ecosystems informed by observable financial momentum?
2. How well are Finnish (cleantech) companies positioned to capture value in these ecosystems?
3. How attractive are the companies from the perspective of market-driven investors?

The structure of the report is laid out accordingly. After a brief introduction of applied methodologies, each ecosystem is treated in a separate section, internally following the sequence of the questions. Each section also includes a discussion of immediate managerial and policy implications. As the results will show, the economic viability and financial investment grade of the three ecosystems differ considerably. They call for different choices with regard to policy instruments that will be discussed in summary in the concluding section of this report.

2 Financial Network Mapping and Value Capture Analyses Expose Industry Risk and Opportunity

To rise to the challenge, we need tools to discover (a) the structure and direction of industrial activity that underlie the selected ecosystems, (b) the value capture potential of individual companies in them, and (c) the types of financing the companies are most compatible with.

2.1 Data on financial transactions reveal the structure of emerging industry ecosystems

To determine whether political vision is substantiated by market-driven industrial momentum, we need to understand the industrial structure and evolution of these ecosystems. To this end, we first need to establish what industrial structures really are.

Industrial structures, fundamentally, are chains and networks of financial and transactional relationships between companies. These include supplier-client relationships, joint ventures, alliances, and R&D collaborations that involve business transactions between two or more companies and can, in the majority of cases, be quantified by the volume of monetary or resource flows.

In alignment with Porter's (1985) concept of the value chain, the configuration of these relational patterns and the variety of functions that companies therein provide characterize the boundaries and value added of any given industry sector. In today's globalized economy, value chains are many times interlinked across conventional industry boundaries to form networks of value chains, or better, value networks or *ecosystems*.

To provide proof of existence for any of the three emerging sustainable industry ecosystems under scrutiny, we need to uncover transactional and financial network relationships between the companies that are active therein. Many methodological alternatives exist. The classic approach involves the use of input-output tables that show quantified value flows between industry sectors and are based on annual industry accounts. The data in the tables are highly aggregated, however, and preclude company-level analyses if needed.

Therefore, we revert to Bloomberg's SPLC (Supply Chain) Module, a new database service by the newsgroup, which provides company-specific information on customers, suppliers, and competitive relationships with peers. For each relationship in the SPLC database it is possible to retrieve quantitative information on the estimated monetary flow and its direction between any two involved companies. Furthermore, each company is assigned an industry code in a number of different industry classification systems (GICS, BICS, NAICS, NACE, etc.), a feature that allows for aggregation of data from the company level to the industry level when necessary.

Combined, these features provide a powerful set of tools that enable analysts to roam and explore the financial network structures in any thematic ecosystem. Starting off with only a few known companies that have been identified to operate in the ecosystem of interest, the links from one company to the next unravel the complex relationship structure. With the help of industry codes associated with the nodes in the network (the blue dots in Figure 1), the resulting findings can be translated to represent connections between industry segments and their centrality in the analyzed ecosystems. The Bloomberg supply chain database is populated for public companies, but the analysis can be extended to private companies as well. Because of limited available information, private companies are listed, but no financial information is available on the value of their transactions in the supply chain.

From a researcher's perspective, the most valuable feature of the approach is, however, that it is purely data-driven. There is no need to pre-specify the companies, industries or boundaries that demarcate the ecosystem *ex ante*.

To gain insights from the results of the financial network analyses, we utilized open-source network visualization software called Gephi[1] (Bastian, Heymann & Jacomy. 2009). Beyond its visual features (see Figure 1), the software provides the functionality to apply key metrics better known from *social* network analysis (SNA) on *industry* network analysis. These metrics include indices for betweenness, network centrality, closeness, clustering, average shortest path, etc. These indices, in turn, help in interpreting the roles that certain companies or industry sectors play in the analyzed ecosystems.

Figure 1 Example of a relational network map

Source: Gephi.

1 http://gephi.github.io/

As will be illustrated using three financial network maps, the metrics for interpretation will identify two types of industries (‘nodes’) in the network. On the one hand, ***anchor industries*** are designated by an absence of network centrality, and a predominance of clustered relationships. These clusters, similarly to the clusters of nodes in Figure 1, are a representation the conventional and often linear value chains of anchor industries. The cross-over between these anchor industry clusters occurs via intermediary industries, or ***catalyst industries,*** as we will denote them. These catalysts are cluster nodes that connect multiple anchor industries, characterized by greater network centrality and multiple financial relationships outside their own cluster.

Financial network maps have been used in a range of financial-economic systems such as economic trade and interbank payment systems to assess robustness and risk in interconnected financial systems. To our knowledge, the application of financial network mapping to uncover emerging industry structures has not been attempted, but ties strongly into industrial cluster strategy approaches that have been advocated in economic development literature. According to the Brookings Institution, a Washington DC think tank, industry cluster analysis can help diagnose a region’s economic strengths and challenges and identify realistic ways to shape a region’s economic future. Yet many policymakers and practitioners have only a limited understanding of what clusters are and how to build economic development strategies around them.

2.2 Value capture analyses assess the strength of Finnish cleantech companies in the emerging ecosystem

Once the structure of an emerging industry ecosystem has been established using financial network mapping, the feasibility and long term viability of Finnish companies to grow such a sustainable economy needs to be systematically evaluated. Specifically, we ask the question:

(a) How are Finnish companies positioned in this ecosystem in terms of value capture?
(b) What type of financing is most suitable for these companies to improve their position and growth?

These questions are engendered from the perspective of understanding the strength of assets in the Finnish economy to drive new growth in sustainable industries.

To this end, we employ a proprietary, data-driven research tool, called KeyStone Compact™, developed by Peter Adriaens and Timothy Faley at the University of Michigan, Ross School of Business. The development work is based on studies of companies from over 600 serial entrepreneurs. In its commercial application by the Keystone Compact Group Ltd, the tool is used to empower entrepreneurs and economic developers with business model and investment risk insights that are typically domain knowledge of sophisticated investors and consultants. The tool subjects companies to two analytical steps: Value capture analysis and investment grade analysis.

The *value capture analysis* focuses on whether the company can capture and retain value from its business, given its position in the value system of the industry where it seeks to innovate. The analysis focuses on mapping out the ‘replicability of the firm’s own *current* capabilities’ against the ‘ease of acquisition of required *complementary* capabilities’ from the firm’s external environment, i.e. other companies and partners. The assessed capability dimensions include the company's tangible and intangible assets, the experience of both the management team and the advisory board, the structure of - and dependencies on - partnerships, and the firm's level of integration (component supplier vs. systems integrator). The analysis is based on 36 dichotomous questions, the answers of which are algorithmically analyzed to produce a quantitative value capture profile for a company, comparable to the Myers-Briggs personality test in its purpose.

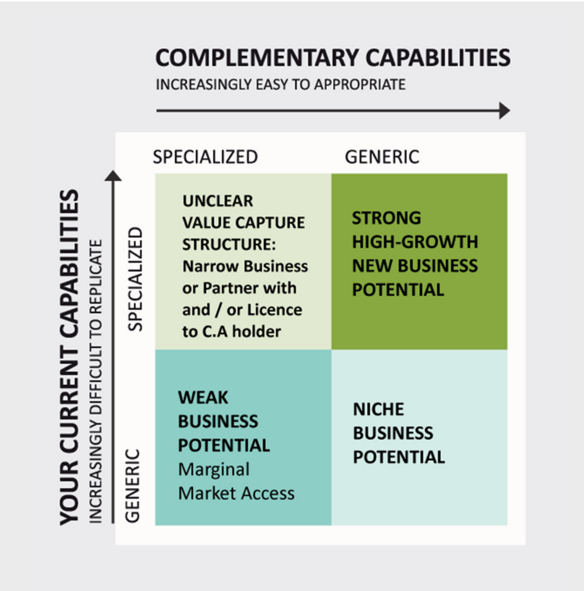
The profile consists of four scores: (1) *Dependency* on partners and third parties' capabilities, (2) *leveragability*, i.e. the capability of a company to exploit its industry connections for promoting its offering and market access, (3) *replicability* of its core capabilities, both tangible and intangible, and (4) *connectivity*, i.e. the quality of connections to the relevant industry and market segments.

The scores translate into coordinates on the results matrix (see Figure 2). Companies are placed into four value capture quadrants: strong high-growth business potential, unclear value capture, niche business potential, and weak business potential.

Companies showing *high-growth new business potential* command specialized and differentiated capabilities that mainly need generic complementary capabilities that are (relatively) easy to appropriate. These companies are expected to capture a lot of value from the ecosystem.

Companies with an *unclear value capture structure* are endowed with specialized assets that are difficult to replicate but require equally specialized complementary capabilities to be exploited. Capturing value from the ecosystem becomes a tug-of-war between the company and its partners.

Figure 2 Value capture matrix



Companies showing *niche business potential* have generic capabilities but only depend on easy-to-acquire complementary capabilities for their business operations. Because these companies cannot compete head-to-head with strongly positioned competitors, they need to identify niche markets that are far less competitive due to their smaller size to capture value.

Finally, companies with *weak business potential* have very generic capabilities and need specialized complementary capabilities in order to productize their offering and deliver it to the customer. In this case, most of the value generated by the company is appropriated by its partners, which wield the needed specialized assets.

It should be noted that all analyses are snapshots in time, and based on the current status of the firm. There is clearly a transition involved when the company pivots into different markets and industry value chains – a company's value capture position shifts over time. It is further important to point out that this positioning analysis is equally relevant for startups and small and medium enterprises (SMEs) seeking to reposition, as it is for large corporate enterprises considering to expand into new lines of business (LOB).

2.3 Investment grade analyses point to the most effective financial instruments to help companies grow

Positioning analysis is an industry view of the company – akin to strategy analysis. Where, how, and to what extent can a company exert and maintain its differentiated capabilities? It does not provide an indication of the investment risk associated with this company. The subsequent investment grade analysis focuses on what type of capital – given their position for value capture – the companies would be most efficiently deployed to build and scale their business. The analysis takes into account whether the scaling is achieved through market or capability adjacencies[2].

To achieve this analysis, another 36 questions allows for mapping the 'upside potential' of the business against the 'time and capital required to scale'. This results in a profile consisting of four investment grade indices: (1) *Diversification* of market and capability adjacencies, which indicates whether the company has identified alternative markets and parallel opportunities for its capabilities in the new ecosystem, (2) *profitability* in terms of explicit and implicit costs and margins, (3) *scalability* of the business model in terms of revenue generation and market access, and (4) *capital efficiency*, i.e. operational capital efficiency and the relative magnitude of additional capital necessary to drive continued growth.

The investment grade scores translate into coordinates that can be categorized into four matrix quadrants (see Figure 3, left panel):

> *Traditional equity investable* companies show potential for significant upside relative to the short investment time horizon and require a higher capital investment rate in order to scale and grow the business. The rate is important because it indicates how quickly a company

[2] A *market adjacency* is a market in which a company can sell a similar product or service. Typically, market adjacencies follow the adoption curve, from early adopters to 'the laggards' (Moore, 1991'). A *capability adjacency*, on the other hand, is a new market for a company that does not leverage its core capabilities. Thus, the company needs to develop (internally) or acquire (externally) products and/or services it currently does not have.

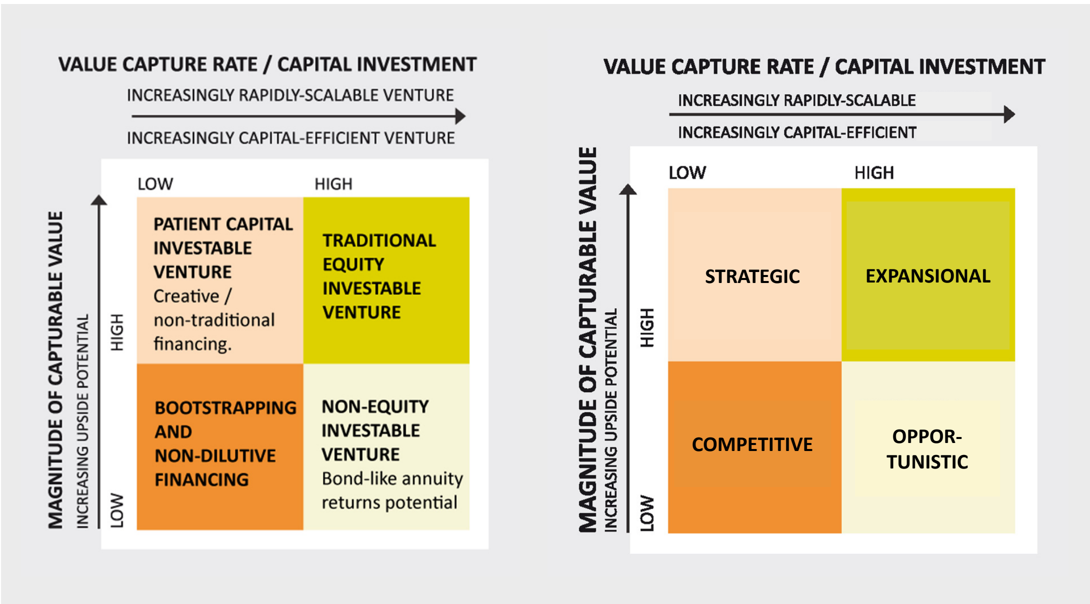
can capture market share, relative to the investment capital required. Capital efficiency is often bandied around in this context. However, it does not mean that a traditional equity investable company necessarily implies lower amounts of investment capital relative to other investments.

Patient capital investable companies are not traditionally equity investable, but can be financed using creative financing options such as mixed debt and minority equity, convertible notes, structured debt, and many other forms of investment. These financing options will involve some degree of equity in the company, either at the time of investment or in the future. Key is the longer investment horizon, and longer time to IRR (Internal Rate of Return).

The *non-equity investable* firms' upside value and time to scale position the investment as an attractive opportunity, but the size of the opportunity and investment required tend to make it unattractive to traditional equity investments. These firms have bond or annuity-like return potential based on their growing free cash flow.

Finally, companies that are currently not attractive to external investors have neither a large upside potential, nor the ability to scale rapidly. They tend to be bootstrapped or rely on non-dilutive financing (grants, subsidized loans). Any of these companies can shift from their current position to a more attractive investment grade by way of strategic and tactical pivots in their business model.

Figure 3 Investment grade matrix



2.4 Investment grade analysis allows corporate enterprises to assess the strategic viability of new a LOB in a changing business environment

How does the KeyStone Compact assessment framework apply to enterprises? Lessons can be learned from the playbook of mergers and acquisitions (M&A) and corporate strategic investments. Large private enterprises differ from start-ups and most SMEs in that they are accessible only by large private equity (PE) firms and private lenders that offer acquisition financing, bridge loans, and recapitalizations intended to position companies for future growth. On the other hand, investments in large public enterprises are restricted to shares and bonds on financial markets. Hence, the investment grade analysis is not applied to provide information on the *compatibility* of the business *with certain types of financing*, but rather to reveal *how attractive* the underlying *market opportunity* – here the smart grid space – is as a possible *new line of business* for the company. It takes the view through an M&A or corporate strategic investment lens.

That being said, the same principles apply to the value capture and investment grade analysis, and the interpretation of the two dimensions that define the matrices. In the case of value capture, the complementary capabilities are those required to access a new market or build out a new LOB. In the investment grade analysis, the Y-axis denotes the *maximum upside potential* that companies can exploit given their current investment strategies, while the X axis measures *the speed* at which the potential can be exploited and scaled.

Using a similar approach to that described for the startups and SMEs, the algorithms place the opportunities as follows (Figure 3, *right panel*):

> *An expansional LOB* places emphasis on the fact that the new business line allows for a substantial increase in market opportunities for the company. The added value and speed required to reposition may drive acquisition activity (acquiring new capabilities and market access) or substantial (re)allocation of internal resources.
>
> *A strategic LOB* tends to be more long-term and does not have the same urgency as the expansional opportunity. For the enterprise, there is substantial upside potential, impetus to (re-) allocate internal resources, and consideration to make investments in companies to help the corporation evaluate its options going forward.
>
> *An opportunistic LOB* is a short-term investment opportunity in a currently more marginal activity such as those driven by a policy shifts, project-specific demands, or a timely acquisition.
>
> *Lastly, a competitive LOB* is essentially driven by wait-and-see industry competition to address the fear-of-missing-out (FOMO) phenomenon. The market opportunity is unclear and longer term, not warranting significant investments, but is affording a hedge position for the corporation.

Clearly, a number of assumptions are involved in both the cases of startup investments and corporate LOB development. However, the KeyStone Compact tools allow for a systematic interrogation of the opportunity resulting from the evolving industry ecosystem dynamics, and bring to bear quantitative analysis for scenario testing. Conversely, the assessment allows for detailed understanding of business model adjustments to meet the scenario that best meets the strategic goals of the company and investment community.

3 CASE STUDY 1 Smart Grid – Advancing Efficiency, Reliability and Flexibility Over Legacy Grid Paradigm

The first application is an understanding of the Finnish smart grid space. Smart grid as a concept is not a recent one, by any means. Demand-side management of electricity was among the earliest applications of a limited 'smart grid'. The grid has gradually become "smarter" as IT-enabled technology has been integrated into the legacy infrastructure of energy production, transmission, distribution and consumption. The proliferation of functionalities is reflected in many of the complementary definitions put forth by the various actors in the smart grid ecosystem:

According to the International Electrotechnical Commission (IEC), a smart grid "is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – to efficiently deliver sustainable, economic and secure electricity supplies[3]. A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies to: (1) facilitate the connection and operation of generators of all sizes and technologies; (2) allow consumers to play a part in optimizing the operation of the system; (3) provide consumers with greater information and choice of supply; (4) significantly reduce the environmental impact of the whole electricity supply system; and (5) deliver enhanced levels of reliability and security of supply."

The European Commission[4] adds that: "Smart grids are energy networks that can automatically monitor energy flows and adjust to changes in energy supply and demand accordingly. When coupled with smart metering systems, smart grids reach consumers and suppliers by providing information on real-time consumption. With smart meters, consumers can adapt – in time and volume - their energy usage to different energy prices throughout the day, saving money on their energy bills by consuming more energy in lower price periods. Smart grids can also help to better integrate renewable energy [...]."

Compared to the legacy paradigm, smart grids offer multiple benefits to their various constituents, some of which are listed by the USDE[5]. These include "more efficient transmission of electricity; quicker restoration of electricity after power disturbances; reduced operations and management costs for utilities, and ultimately lower power costs for consumers; reduced peak demand, which will also help lower electricity rates; increased integration of large-scale renewable energy systems; better integration of customer-owner power generation systems, including renewable energy systems; [and] improved security."

To summarize, smart grids create added value in the form of enhanced *cost efficiency*, greatly improved *reliability* and unprecedented production *flexibility*. Because the related benefits are appropriated by both producers and consumers, the emergence of smart grids is driven by forces of both demand pull and supply push.

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3 http://www.iec.ch/smartgrid/background/explained.htm (last access OCT 12, 2015)

4 https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters (last access OCT 12, 2015)

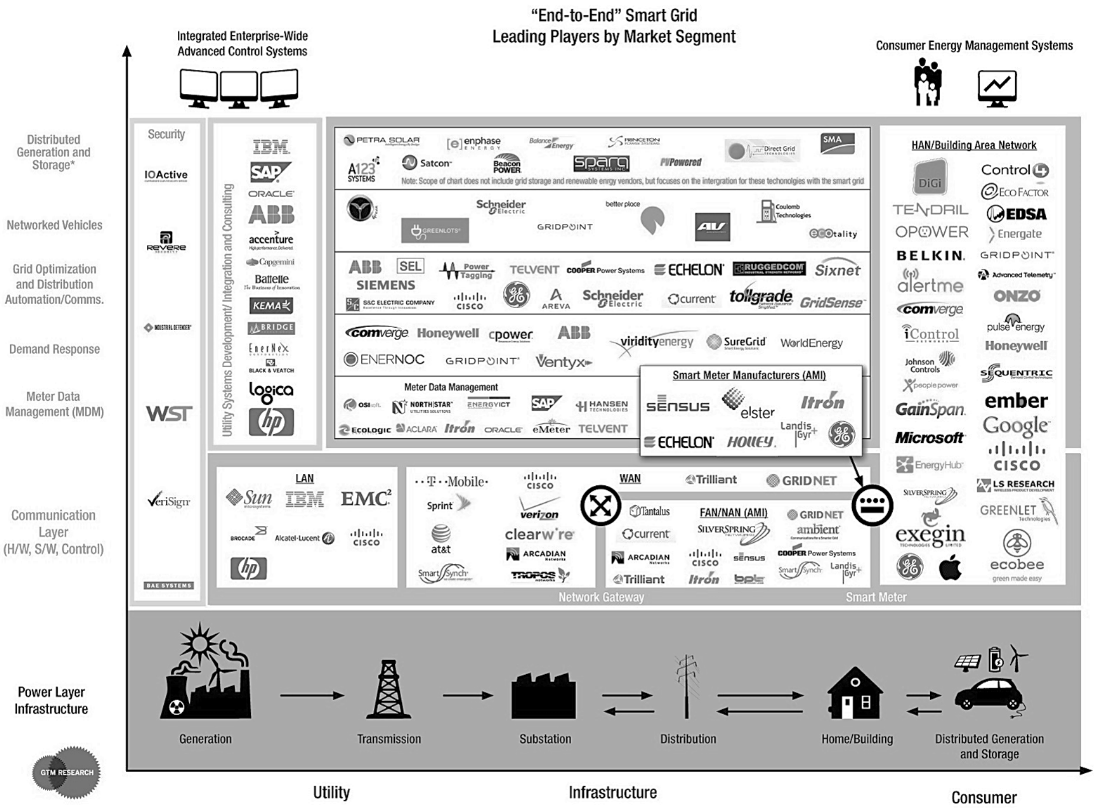
5 https://www.smartgrid.gov/the_smart_grid/smart_grid.html (last access OCT 12, 2015)

3.1 Smart grids are cross-industrial ecosystems

The definitions strongly imply that smart grids transcend the traditional boundaries of the energy production and transmission value chain. Monitoring, bi-directional data flows, machine-to-machine communication and electronics that enable automated optimization on system level are not in the capability domain of traditional utilities and transmission grid operators. A few years ago, Greentech Media Research developed a plot of smart infrastructure layers on top of the traditional infrastructure value chain (Figure 4). While some companies represented in the figure no longer exist, have been acquired, or gone out of business, the structure reveals important features of the industry ecosystem.

While the incumbent energy value chain is represented in the familiar power infrastructure layer (bottom), smart grids necessitate the integration of a large number of other functional layers that build on top of the incumbent infrastructure. These include the communication infrastructure across which data is transmitted between the different stakeholders to the system; the meter data management layer; the demand response layer which exploits multi-source data to provide services for the optimized co-ordination of energy production and demand; the grid optimization layer which translates the data-based demand-response predictions into physical control of the system infrastructure; and the storage layer, which acts as a necessary

Figure 4 Smart grid industry layers



Source: GTM Research, 2011.

buffer between peaks and troughs introduced by both volatile demand and renewable-based production of energy.

A closer look at the respective companies in the various layers of the smart grid ecosystem demonstrates that the structure of the system is highly cross-industrial. Indeed, it involves industry sectors and segments ranging from energy to telecommunications and software development; from machinery to industrial electronics and data analytics; and from computer hardware to home electronics and infrastructure construction. But how do these companies financially interact to form the ecosystem? What does the industrial skeleton – the value network – of the ecosystem look like?

3.2 Data, software and IT are the beating heart of the smart grid ecosystem

Subjecting the ecosystem to the financial network mapping analysis reveals the monetary flows between the involved sectors and subsectors, and shows the intricate industrial structure of the entire system (Figure 5). It is important to note that the input data employed were selected at the six-digit GICS (Global Industry Classification System) level, well below the broad industry sectors. Hence, the network map reflects an integration of value chain data in the context of sub-sector groupings of industries (companies) with similar business activities. Even if business activities are similar, their respective business models may diverge significantly.

Starting with the top most panel of the figure, the edge thickness of connections between individual industry sectors denotes the relative financial exposure – i.e. the relative flows of money – between them. The thicker the edge, the more significant is the financial exposure (trade relationship) between the industries. Another key dimension in the map is the positioning of the industries relative to each other. Those positioned closer to the core of the map display a higher connectivity, or *network centrality*, to all other industries than those located in the periphery of the map. The higher the centrality, the more "important" the respective industry is to the mutual connectivity of the entire ecosystem. Industries of high centrality bridge the chasms between sectors that otherwise would have very low connectivity in a given ecosystem. Aside from social networks, this observation has been made in financial networks as well.[6]

As displayed in the lower two panels, we use the centrality of nodes to distinguish between the roles single industries have in the financial network structure of the smart grid ecosystem. Industries of high centrality – encircled in blue in the figure – are designated *catalysts*. They are built on the infrastructure of *anchor sectors* that stake the perimeter of the ecosystem.

Anchors are less well connected to the emerging ecosystem as they are still relatively contained in their incumbent industrial value chains. However, they serve an extremely important role as the providers of capital-intensive infrastructure and vital technological components. Good examples of essential smart grid infrastructure are *energy production facilities* and *transmission grids* maintained by utilities and grid companies as well as the *telecommunication networks* maintained by both integrated and wireless telecommunication operators. *Technological components*, in turn, are provided by electrical component and equipment manufacturers, industrial conglomerates, such as Siemens, Bosch and others, and communications equipment producers.

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6 See Soramäki and Cook, 2016. Network Theory and Financial Risk.

The role of *catalyst* industries, in turn, is the integration of the aforementioned sectors to harness them for creating entirely new type of value that will be offered to users in the form of novel products and services. In the case of smart grid, this means, increased efficiency, reliability and security through real-time, data-driven optimization technologies and services. One could argue that, in the case of smart grids, it is the catalyst industries that make the system intelligent – an internet of things (IoT). Catalyst industries include many software-based sectors such as *systems software*, *application software* and *data processing*. *Semiconductors* as well as *technology hardware and storage* further corroborate the centrality of IT-related solutions in tying together the intricate web of industrial activity in the smart grid ecosystem.

3.3 Smart grid ecosystems display true industrial momentum

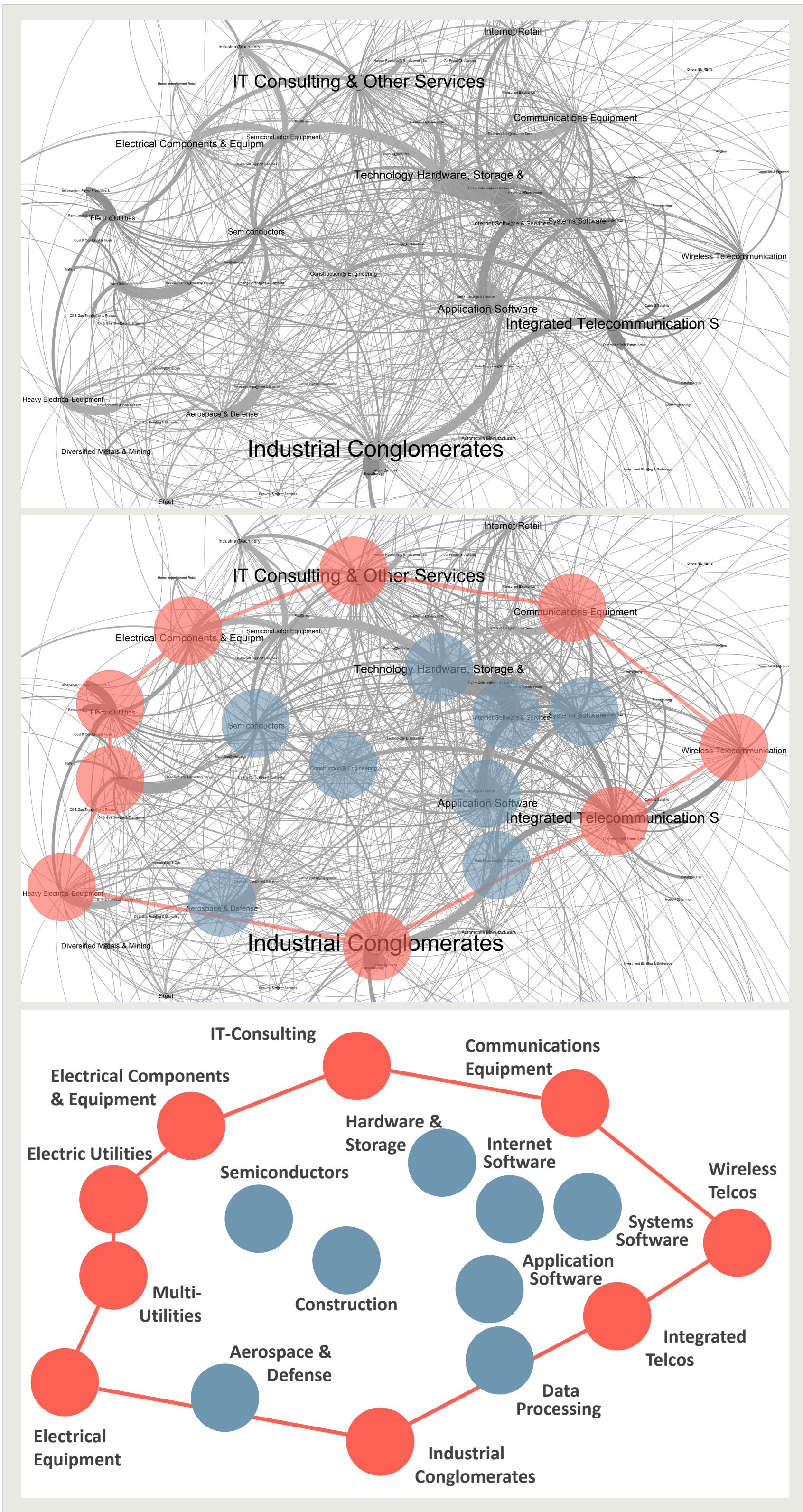
Now that the industrial structure is understood from the perspective of financial network maps, we can answer the first question that guides our analyses: *Is the concept of smart grid supported by observable industrial momentum*? The data indicate that smart grid business clusters have transcended political vision. The cluster has become economic reality, knitting together legacy industries with IT-based sectors into a robust industrial ecosystem.

This begs the question whether catalyst or anchor industries tend to capture most of the value generated in the ecosystem. A look at the substantial monetary flows towards and between these catalysts (see edge thickness in Figure 5) alone does not yet provide sufficient evidence of high value capture rates; they merely indicate the gross throughput of monetary flows and are agnostic of how much which sector retains of it. Corporate finance measures such as gross margins or operational margins, fixed asset turnover, and the like provide further information on the value retention by the industries.

3.4 Telecommunication industries are better positioned to hop on the smart wagon

As an interesting final remark on the ecosystem's structure, the catalyst sectors seem to be more closely affiliated with telecommunications-related sectors than with energy utilities or component manufacturers. The close relationship is a tangible legacy of the internet era that witnessed the convergence of telecommunications providers, software developers, and data analytics services to create the still quickly evolving internet ecosystem. These relatively close ties will put telecommunications providers in a more advantageous position to capture value in the smart grid space as they already form an important part of the respective ecosystem structure. One of their most valuable assets is an existing, proliferated and captive customer and payment interface that reaches every single individual with a phone or internet connection. Telecommunications companies such as Nokia and Cisco have indeed engaged in strategic investments or acquisitions of home, local area, and geographic network and security companies to enable the roll out of new smart, digital service through their interface.

Figure 5 Smart grid industry ecosystem



Data from D. Assanis based on Bloomberg SPLC data.

3.5 Finnish smart grid companies show differences in current performance by company size

Now that the economic momentum of the smart grid space has been established, the question how well Finnish companies are positioned to exploit it becomes a lot more relevant. To address this question, we have gathered information on Finnish companies with the same GICS/NACE code as those that emerged from the nodes in the financial network map. The companies and their associated financial information were selected from the Statistics Finland database.

To start with rough descriptors, Table 1[7] provides a brief overview of key financial indices that highlight differences in the Finnish smart grid company universe by company size[8]. The results are fairly intuitive across the three size classes: Larger, well-established companies appear to be outperforming their smaller peers in every aspect save the EBITDA margin, which is the stronghold of SME-sized businesses. In extension, the poor performance of start-ups is expected. The immaturity of target markets, the early stage of business development and the focus on a single line of business all play into the weak financial metrics so characteristic of many young start-ups. The overall poor profitability across all size categories, on the other hand, is less commendable albeit in line with earlier findings on the Finnish cleantech business space in general (Kotiranta et al., 2015). Clearly there is room for improvement irrespective of company type.

We will not further speculate on the reasons behind the descriptive findings and caution the reader to draw categorical conclusions on the vitality of the Finnish smart grid industry based on these figures alone. For one, smart grid is still an incipient industrial space, in which com-

Table 1 The Finnish Smart Grid industry performance in numbers

Metric	All (n=96)	Start-ups (n=12)	SMEs (n=39)	Enterprises (n=44)
Personnel	375,7	32,1 *	51,4 *	751,3 *
Value added (€ mill.)	32,1	2,1 *	4,5 *	70,7 *
Turnover (€ mill.)	222,2	5,1 *	8,7 *	471,6 *
EBITDA %	-5,9	-59,0	4,6	-0,5
Equity ratio %	27,5	-15,7	21,2	44,7 *
Current ratio %	2,3	1,3 *	2,1	2,7
ROI %	10,0	-18,9	10,1	18,1 *
EBIT %	-12,2	-84,3 *	-2,9	-2,3
Quick ratio %	2,1	1,3	1,7	2,6
ROA %	5,4	-6,4	4,4	9,6 *
Net profit %	-14,3	-84,9 *	-4,9	-4,8
Alpha rating (99-7)	23,5	32,5	29,1 *	15,5 *

7 Results are winsored (2.5%) arithmetic averages. Asterisks signify statistically significant, t-tested results.

8 *Start-ups* and *SMEs* both employ less than 250 individuals. The former are also less than five years old, the latter are not subject to an upper age limit. *Enterprises* employ 250 individuals or more. Many of them are also public. Revenue, total assets and other financial metrics have not been applied in the size categorization.

panies irrespective of their historic trajectory and age are still searching for scalable business models and value system entry positions. The opportunities will become fully monetizable as the space matures. Secondly, few of the companies involved are pure players with an exclusive focus on the smart grid business. The aggregate financial indices reflect, among other things, the business performance in other lines of business the companies pursue in parallel. Finally, the results in Table 1 represent a cross-section – a single snapshot in time – of the companies' performance as measured in 2013, and, as the volatile and time-sensitive indicators they are, should not be interpreted as reliable measures for general, representative financial performance.

> To gain more relevant insight in the sector's potential we take distance from the measurement of current performance, which overemphasizes the companies' historic trajectories, and instead revert to an capability-based assessment methodology that gauges the sector's future potential, using the Keystone Compact™ suite of tools described earlier.

3.6 Value capture potential builds on low partnership dependencies and high differentiation of assets

The Keystone Compact™ toolset assesses the potential of individual companies in two stages. For a more detailed description of the methodology, please consult the methodology section above.

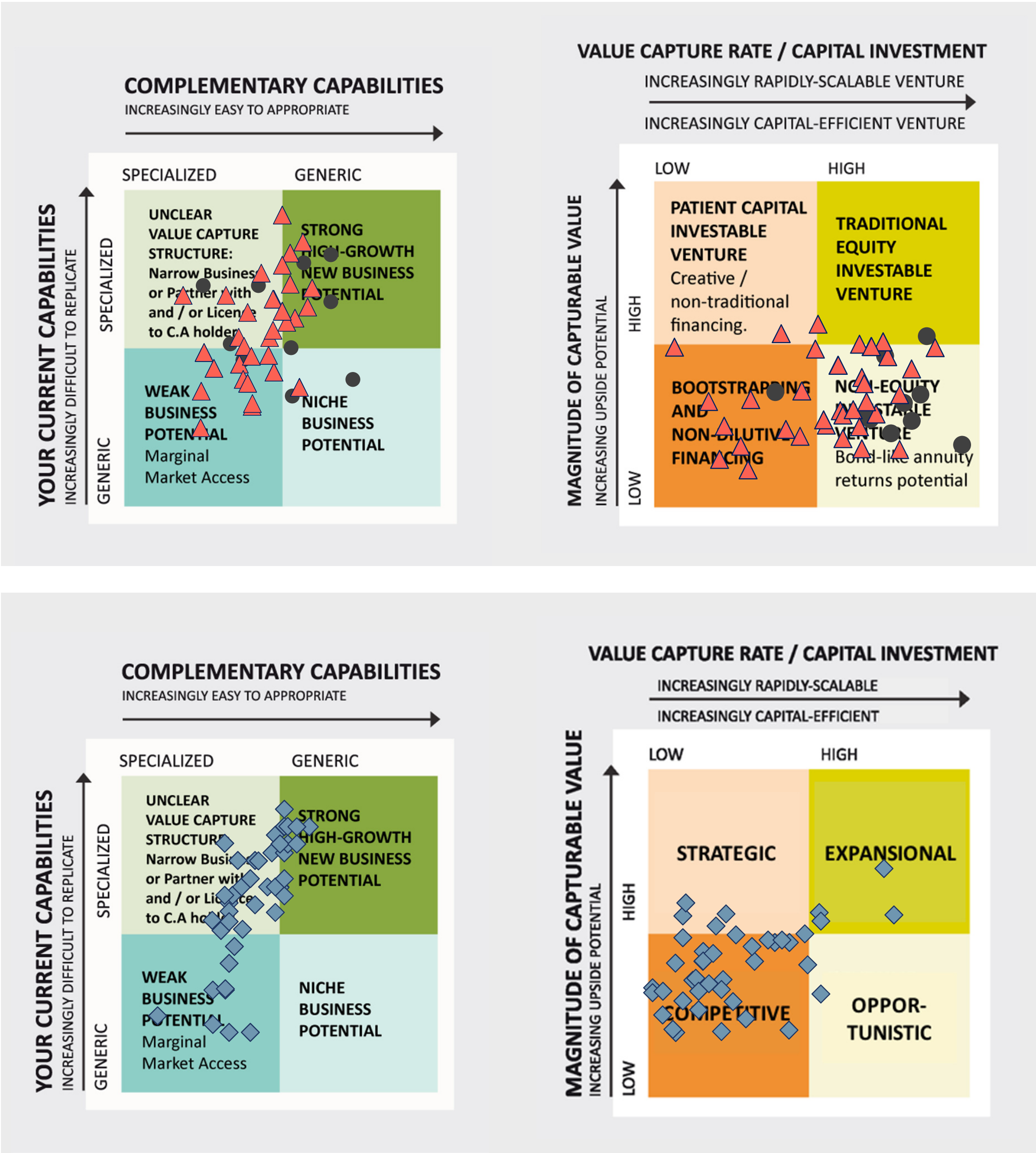
Displayed in the left panel of Figure 6, the first stage gauges the strength of the position a company commands in a *specific industrial ecosystem*. The analysis rests on the fundamental assumption that a company's capability to capture most of the value it generates depends on the degree of control it asserts over relevant core assets vis-à-vis other stakeholders in the ecosystem. The less dependent a company is on specialized assets controlled by 3rd parties, the better is its capability to capture value from the ecosystem. It is important to note that the results are specific to the industry ecosystem where the company intends to compete. Pursuing multiple lines of business, many more mature companies operate in different ecosystems simultaneously. The results presented here are specific to the smart grid space.

A glance at the left panel of Figure 6 reveals that, overall, Finnish smart grid companies are fairly well positioned. As the distribution across the four quadrants shows, a very decent share of the 96 companies displays high-growth business potential. Differences between company types as defined by size are hard to discern, i.e. none of the three company types consistently outperforms the others based on the KeyStone metrics.

Results presented in Figure 7 corroborate the visual observation: the four drivers that determine a company's value capture potential – dependency on third parties, leveragability of 3rd party assets, replicability of the company's capabilities and the connectivity of the company to the relevant ecosystem – do not show statistically significant[9] differences between start-ups, SMEs and large enterprises. That being said, Figure 7 does provide insights as to which of the four drivers specifically contribute to the fairly strong positioning of Finnish smart grid companies. Two of them stand out in particular:

[9] The results shown in Figure 7 are *t-tested* arithmetic averages of the respective Keystone Compact™ metrics.

Figure 6 **Value capture (left) and investment grade (right) analysis for emerging businesses (grey), SMEs in business longer than 5 years (red), and large enterprises (blue) active in or positioning for Smart Grid LOBs**



The first is a generally *low dependency* on third party assets. This implies that the companies exercise control over the relevant core assets – both *tangible assets* in the form of production facilities, information systems and infrastructure as well as *intangible assets* such as human capital, trademarks, and patents – needed to create their offering. The companies tend to be either highly integrated or serve as system integrators to generic component suppliers, in which case they have a broad enough choice of partners to avoid lock-in. In parallel, the dependency on strong partners for market access is similarly low, which helps to appropriate a larger share of value from end-user markets. The decent overall *connectivity* to the ecosystem, a separate driver of value capture in itself, further promotes the companies' freedom to operate in the emerging industry space.

The second driver is the *difficulty* of competitors and partners *to replicate the companies' capabilities* in generating value. The positive results with regard to replicability speak of both strong intellectual property protection strategies as well as the presence of experienced and capable management teams that can leverage their accrued skills in navigating the emerging business ecosystem. This human capital is tacit in nature and therefore hard to copy or imitate.

3.7 Leverageability is the unfortunate chink in the armor

Of the four drivers presented in the left panel of Figure 7, *leverageability* clearly is the weak spot of Finnish smart grid companies. While *dependency* measures the strength of influence that external parties exercise over a company, *leverageability* measures a company's ability to exploit its assets and partners to its own advantage. This includes the tangibility of core partnerships via contracts, joint ventures and other agreements but also the fierceness of the competitive environment and the degree of concentration in the industry, i.e. the market structure. Tough competition, an oligopolistic market structure and frail partnerships all gnaw at overall leveragability of company assets.

While the relatively weak *leverageability* does not seem to critically affect overall *value capture potential*, it has major indirect impact on the *investment grade* of the companies, as will be shown shortly. In particular, it has a strong inhibiting effect on the value that companies can normally reap from the diversification of their capabilities and markets.

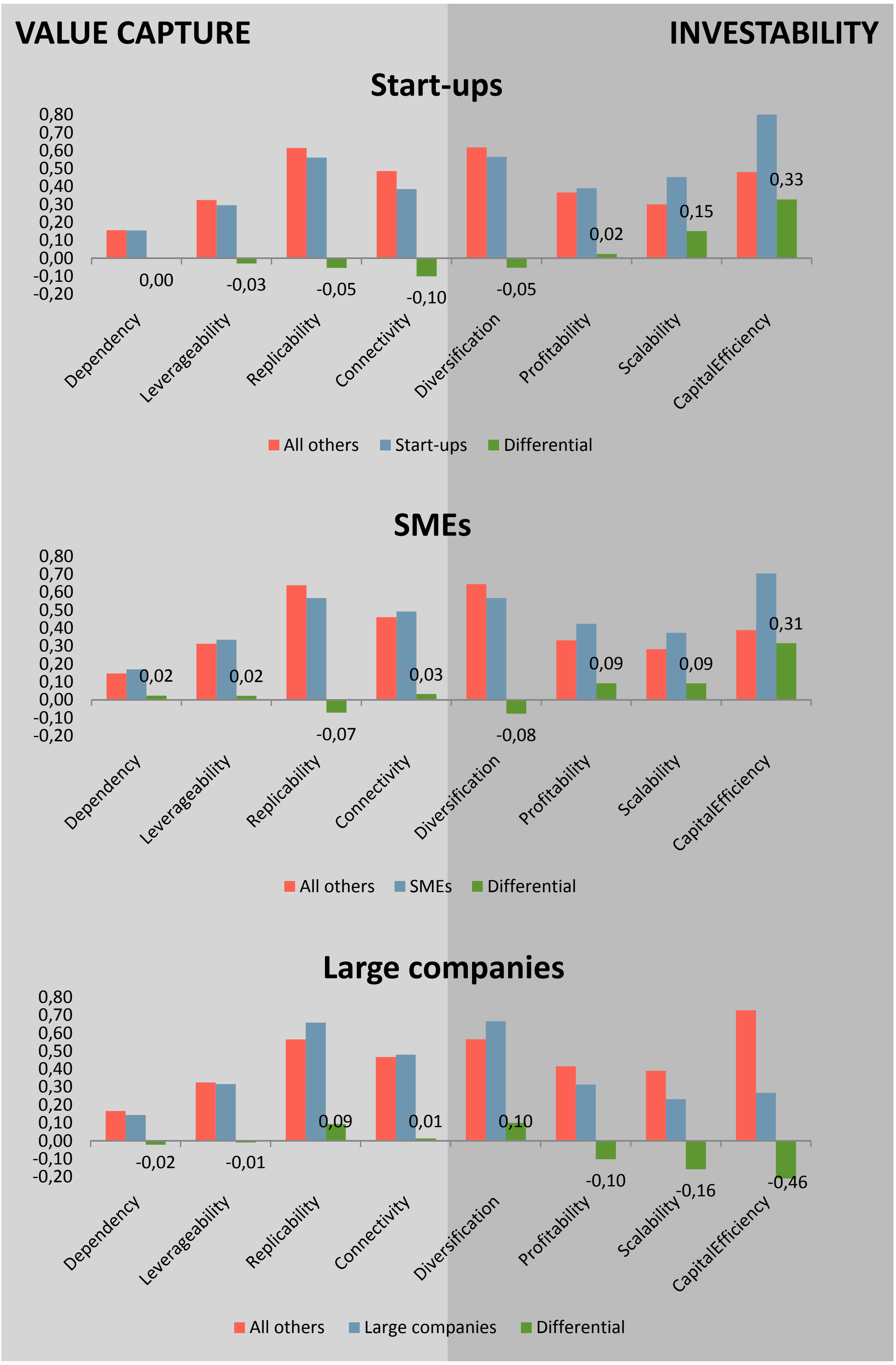
3.8 Low expected profitability and the mediating effect of low leverageability gnaw on firms' upside potential

The results for *investment grade* – see the right panel of Figure 6 – provide for striking insights. Across the board, irrespective of company type, the upside potential seems to be rather marginal; the great majority of companies finds itself in the lower two quadrants of the Keystone Compact™ investment grade matrix. Supported by the results shown in the right panel of Figure 7, two main drivers can be identified for the phenomenon.

The first driver is a relatively low *expected profitability*[10]. The expected profitability of companies depends on a variety factors. These include the competitive structure of the targeted markets, their respective growth rates, the degree of commoditization of the companies' offering, expected margins typical for the targeted industry, the degree of separation from the end customer, the degree of recurrence in the revenue model and, finally, the degree of control over the sales channels.

[10] For interpretation's sake, it is crucial to note at this point that profitability here is not measured based on past or current performance of the assessed companies. It is an approximation of the average performance of already estab-lished companies running a similar business model in the industry sector that the focal company strives to enter. One could say, profitability here reflects the potential upside that a given company can expect to tap into if the entry into the targeted ecosystem is successful.

Figure 7 **Value capture and investment grade drivers of the Finnish smart grid sector by company type**



Given these factors, what can companies do to improve their prospective profitability? Many of the listed factors relate to the competitive structures, growth rates and average profitability of the respective markets. These are factors that are in part external to the company as the result of systemic risks. However, risk management strategies are highly dependent on new business models such as those driven by data and services. There are two options that any company has when faced with unfavorable market conditions.

The first is to *seek out new markets* with more favorable conditions. However, pivoting to new, less competitive and less concentrated markets with higher average profitability is a daunting task for any organization with a relatively fixed set of often market-specific skills and networks. To use a somewhat loose allegory for support, it is difficult for a lawyer to become a medical doctor because the required assets and skills are quite different and hard to adopt in a mere strategic move.

The second option is to *adapt*. This could encompass (a) new *value chain strategies* that emphasize gaining control over and shortening the relevant channels to the targeted markets, and (b) *re-designed business models* with a focus on creating multiple and recurring revenue streams.

Amongst many options, *new value chain strategies* can take advantage of the progress made in digitalized technologies, for instance, that help to move from physical distribution networks to generic on-line distribution platforms. These inherently have global reach and are not based on exclusive and captive distribution contracts.

As for *new business models*, moving from classic *make-and-sell* models to *anything-as-a-service (XaaS)* models (a manifestation of servitization) has been somewhat of a trend, which provides for recurrent sales revenues in conventional and emerging industries alike. A XaaS -approach brings particular benefits to manufacturing-driven businesses – such as component or sub-system manufacturers – that produce long-lived capital goods. In these businesses, resale cycles are long and, therefore, sales occur sporadically. A component-as-a-service model would provide for valuable customer lock-in effects and generate steady revenue streams, as well as benefit the capital efficiency of the operations. For the customers, on the other hand, the benefit is in not having to make expensive investments into capital goods that will pose a capital risk and have a major impact on key financial metrics such as Return on Capital Employed (ROCE).

The second driver behind the marginal upside potential (Figure 6, right panel) is the previously discussed inhibiting effect that the seemingly low *leverageability* of the companies has on the benefits they could reap from their otherwise high degree of market *diversification* (Figure 7, right panel). Besides measuring the maturity of the industry – here smart grid – and the control that large enterprises have over it, the *diversification* metric indicates whether companies have identified opportunities to exploit their offering and capabilities on alternative, adjacent markets. These could serve as additional growth opportunities either by re-positioning the entire business or through additional lines of business. As asserted by the results, the companies in the Finnish smart grid industry fare reasonably well in this dimension.

However, their weak ability to leverage proprietary asset strength against other stakeholders (suppliers, customers, and competitors) in their industry ecosystem (Figure 7, left panel), significantly hamper their opportunity to take advantage of valuable market diversification strategies. *Leverage* is the benevolent twin of malevolent *dependency*. Companies should avoid strong dependencies on partners to avoid being marginalized or commoditized, but a weak ability to leverage their strengths for growth is equally detrimental to business. Often, this is the result from competition on price, rather than on value. It is a deterrent to reaching maximum potential, which is captured in the weak results for investment grade in Figure 6 (right panel).

3.9 Large enterprises exhibit a very cautious approach to enter the smart grid space

Figure 6 provides for a final, yet very telling insight: large enterprises fare particularly poorly in terms of investment grade. With few exceptions, the cluster of large smart grid enterprises locates mostly in the lower left quadrant of the Keystone Compact™ investment grade matrix (Figure 3, right).

As a brief review, the upper-right quadrant represents high-potential opportunities that enterprises can turn into value relatively quickly, using strategic acquisitions to acquire new market share, in-licensing and other expansional strategies. The upper-left quadrant represents high-potential opportunities that can be captured via long-term projects and strategic acquisitions to acquire new skills or technologies. The lower right quadrant is the space of opportunities that will be pursued for more opportunistic reasons: the overall value of the opportunity may not be particularly high, but it is quick to exploit and will not require large investments, often internal. Finally, the lower left quadrant, the space in which most Finnish smart grid enterprises are positioned, defines prospects that do not show particularly high upside potential nor are quick to be exploited; the opportunities are wait-and-see and not explored for direct significant financial gain.

The obvious question is, why are Finnish enterprises with activities in the smart grid space overly conservative? Is the reason capital resource conservation? Or risk aversion in an uncertain market environment? Perhaps they are cautious to sound out a new opportunity space, the economic prospects of which still remain somewhat vague?

A more tangible indication of possible causes is provided in Figure 7 (right panel). The companies score extremely weakly in both *scalability* and *capital efficiency* when benchmarked against their smaller counterparts. Average *capital efficiency*, in particular, is extraordinarily low. These two drivers determine the speed at which any given opportunity can be exploited and scaled, and push the majority of enterprises into the lower left quadrant in Figure 6.

To extract insights from the findings, we need to break down the drivers in more detail. A low *scalability* score is indicative of a business model with long sales cycles and limited opportunity for value capture through diverse revenue models. In addition, the degree of synergy of the pursued business with the enterprise's other lines of business, the degree of commoditization of its products and services, the length of the typical sales cycle from sales lead to conversion, the ease of integrating the product or service into the customers' processes, the dependency on external sales channels, the maturity and concentration of the target market as well as the degree of regulation in the target market affect scalability.

Low *capital efficiency*, in turn, is driven by high investment requirements in physical assets for growing revenue streams, a focus on the production of physical products, low economies of scale in the production, and a low asset turnover rate typical for companies operating in the targeted industry segment.

In light of the findings we can then argue that Finnish enterprises are seemingly intent on entering the smart grid space with a choice of *conventional* strategies, relying on practices and models they know best from their legacy businesses: manufacturing-centric, capital intensive business models combined with slow-cycling sales models that are well suited for mature capital good markets, but are too sluggish and inflexible for capturing value in the fast growing, data- and analytics-driven smart layers of the emerging ecosystem.

Our earlier work (Kotiranta et al., 2015) shows that manufacturing businesses are the clear center of gravity in the Finnish cleantech space, even more so than in the domestic industry in general. In the gold rush era of digitalization, a heavily manufacturing- and engineering focused company base can quickly become the ball-and-chain to the mid-to-long-term growth of the industry. Hanging on to the legacy comes with the risk of being pushed to the proverbial periphery of the growing smart grid ecosystem. The ecosystem map in Figure 5 provides tangible evidence of this trend: Telcos as well as software and data analytics companies currently fight for dominance over the demand-response space, an area in which power utilities *could* reign superior given their control over the most central of physical assets, namely the power generation and transmission infrastructure.

3.10 Smart Grid enterprises need more aggressive entry strategies to avoid marginalization

Our results confirm that a global, economically viable Smart Grid financial network is a reality. Power utilities, electrical and mechanical component and systems manufacturers, information and communication technology producers as well as telecommunications operators form a strong infrastructure layer that provides the physical foundation for the entire smart grid ecosystem. This foundation integrates power generation technology, transmission and distribution grids, the respective electronic and mechanical equipment as well as telecommunication grids and their control technology.

On top of the foundation, data and software -driven companies build scalable, fast growing businesses, leaning on the resources of the entire infrastructure layer. In doing so, cross-industrial value chains emerge and enable the creation of service models that add new value in the form of improved efficiency, reliability and flexibility. It is these companies that connect the involved legacy industries to form the emerging ecosystem and to make it “smart”. IT-hardware developers, data storage companies, application and systems software developers, as well as data processing and analytics companies are in this growing nexus of the smart grid ecosystem. Machine-to-machine communication -enabled grid and facility automation, remote controlled smart homes and factories, micro-grid integration, demand response optimization, and predictive grid maintenance services are just few examples of new value added products and services powered by IT- and software-driven solutions.

How do Finnish companies fare on this stage? Given the well-publicized strengths of the Finnish industry structure, one would argue that the odds are in the country’s favor.

In the infrastructure layer, Finland has a long-standing legacy in power electronics and mechanical engineering with a particularly lively, international cluster around the westerly located city of Vaasa. Furthermore, Finnish power utilities had to face the open and competitive electricity market amongst the first in the world as the electricity markets were liberalized in Scandinavia as early as in the mid-1990s. In a sense, they have had a head start in designing competitive strategies and adopting smart solutions to stay at the edge in the highly commoditized market place.

Many of the same arguments apply to the Finnish telecommunications sector. With the rise of Nokia driving an explosive national and global adoption rate in mobile telephony in the same time period, the Finnish telecommunications operators faced a fast growing market place that was gagging for ever larger bandwidths and smarter services such as journey planners, digital tickets for public transportation and other flexible on-the-go solutions that helped make everyday life more efficient, less stressful and spontaneous. They, too, have had time and incentives to respond to a very demanding clientele that expected smart solutions from the start.

However, our results show that the incumbent players in the infrastructure layer, despite their robust position to capture value from the smart grid ecosystem, have adopted a non-aggressive entry strategy. Their strong value capture position is encumbered by capital intensive, manufacturing-driven, production business models that are difficult to scale rapidly. Instead of strategically positioning themselves into the high-growth sectors of the smart grid ecosystem, Finnish enterprises have continued to provide their incumbent and highly commoditized products and services – such as electricity by the kilowatt-hour and data transfer by the megabyte – to the ecosystem. These commodities are important, no question, but the attractive margins and growth in value is in the scalable services and related products that help customers save costs through digital optimization and predictive maintenance, improve the comfort of living through home automation and user interaction, as well as improved risk management through self-healing grid technologies and intelligent security solutions. Continuing to rely on commoditized and generic product and market strategies puts enterprises in danger of becoming marginalized and being pushed to the periphery of the ecosystem. They will still remain vital as the producers of the necessary core commodities, but the value will be captured by companies in the growth sectors of the system.

What can power utilities, component manufacturers and telcos then do to reposition them for improved value capture and growth?

In the US, some telcos have been particularly aggressive. Verizon, for instance, has invested into its own energy production capacity, and now powers its own facilities. Verizon hardly competes with energy utilities for a share in a low-margin regulated commodity business, but uses investments to learn about the dynamics and technologies of renewable energy generation, grid integration, micro- and off-grid technology, power distribution, demand response optimization and consumption prediction. It is a test laboratory in Verizon's own backyard that enables the company to develop and adopt an entirely new skillset for providing cutting-edge solutions without the historical baggage of legacy companies that are too slow to capture value in the smart grid ecosystem. At the same time, the company benefits from the goodwill their sustainable and independent energy setup imparts on the Verizon brand.

Less aggressive strategies build on acquisitions. Again, US contenders are more courageous in the adoption of this strategy. Many of the companies pictured earlier in Figure 4 do not exist anymore because they have been bought out by peers, suppliers or customers in both horizontal and vertical acquisition strategies. There is an acquisition frenzy sweeping across the smart grid landscape as companies across industry boundaries compete for the largest piece of the still growing smart grid pie.

But why would companies make such risky commitments in face of the still somewhat vague economic promises made by smart grids? Isn't partnering, for instance, a more flexible and less risky option to probe the emerging space?

An acquisition strategy has one major advantage over pure partnering strategies, the least aggressive of options: the buyer internalizes the value the acquiree would otherwise capture from the growing ecosystem. In our company analyses we often encountered enterprises that claimed to have committed to becoming a key provider of smart grid solutions. On a closer inspection of their respective business models, however, it turned out that the enterprises' role in these solutions remained that of the conventional commodity provider. At the same time, a number of their partners – sometimes tens of them – contributed all the smart elements and captured their associated value. Sure, large incumbent enterprises can charge a certain margin for their role as an integrator of these elements and for providing a market channel to the often much smaller partners but the dependency on a partner's specialized capabilities in the emerging smart grid space compromises this advantage. A lot of potential synergies are left on the table. Furthermore, the appropriation of relevant capabilities, a prerequisite to long-term success in any environment new to a company, is difficult in an arms-length, contractual relationship, in which partners are understandably reluctant to disclose their core capabilities.

That being said, partnering is a justified first step in entering into the smart grid ecosystem. It provides consortia of companies the possibility to capture an increasing share of a fast growing market space. Sometimes speed is crucial to the establishment of a competitive position. The objective for corporate consortium partners, then, is to exploit the partnerships to validate potential market opportunities, acquire the required core capabilities for long-term success and aggressively leverage their superior resources to establish their presence in the new market.

3.11 Legacy infrastructure and digital market platforms offer improved market access for Smart Grid SMEs

According to our results, start-ups and SMEs are quicker to tap into the smart grid market potential than their large corporate counterparts. Their business models are more *scalable* and, most decisively, exhibit a much *higher capital efficiency*. This gives them the capability to capture opportunities faster. Figure 6 clearly shows that the majority of start-ups and SMEs are in the lower right quadrant of the investment grade matrix.

This is a strength worth preserving. As argued earlier (Kotiranta et al., 2015), the make-and-sell business model, the stalwart of the traditional CleanTech economy, is being eroded by service models with recurring revenue streams and low capital intensity. CleanTech 3.0 has been defined by business models that have been built on top of legacy infrastructure, and has given rise to the cleanweb. ICT and network-based technologies are at the core of the transition from cleantech to cleanweb. A decade after cleantech was defined as an innovation space, the convergence between ICT and cleantech holds the key to scale and profitability. Given the pre-eminence of Finnish companies in this area, and a rich industry value system in this space, there is clearly an opportunity to be tapped and assets to be leveraged. Our current results imply that SMEs in the smart grid space are well positioned to do just that, given their fairly good scalability and excellent capital efficiency.

However, both start-ups and SMEs suffer from the same weakness that seems to be characteristic of the entire ecosystem: poor *leverageability* of industry capabilities needed to gain access to markets. It is an unfortunate deficiency since there are ample market opportunities to be exploited given the deregulation of the energy industry and diversification in the telco industry. However, the necessary value chains – the cross-industrial structures that we mapped earlier (Fig. 5) – are too undeveloped to sustain growth of a scalable market. It is safe to consider the Finnish Smart Grid industry an incipient economic sector.

There is a need for building out a growing smart grid industry cluster and market. As a first step, start-ups and SMEs could work with large enterprises to address their energy needs. Small firms can leverage the market infrastructure of large enterprises to gain access to the global market place. Therefore, in the short term, a partnering strategy offers a synergetic opportunity that both small and large firms could benefit from. Indeed corporate strategic investors have increasingly turned to the development of corporate incubators with small companies. The objective is to align innovative product offerings with corporate lines of business. In the long term, however, once the necessary capabilities have been acquired, large enterprises have the incentive to use their asymmetric market power to capture most of the value generated in consortia.

Small and medium –sized companies, therefore, are advised to develop parallel value chain strategies independent of large industry connections. Progress in generic, digital market platforms is a promising venue that helps small companies to scale their offering onto global markets without having to lock into market channels controlled by dominant enterprises or having to invest heavily into building costly proprietary market infrastructure.

3.12 Partnership programs, cross-industrial pilots and governance standards for net works of IT systems are effective tools in promoting industrial momentum

Our findings give rise to a number of policy recommendations. First, the smart grid ecosystem seems to have gathered industrial momentum to grow in a sustainable manner. As shown, a number of conventional legacy industries contribute the necessary commodities and infrastructure for more agile – and often digital – sectors to build new value added services onto. However, a closer look has revealed a weak connectivity of the companies to appropriate market channels that would allow them to exploit the momentum. As an initial measure, both large enterprises as well as SMEs would benefit from synergetic partnerships that give incumbents access to their specialized capabilities, and provide SMEs with a possibility to leverage the incumbents' superior market infrastructure as a channel.

To accelerate the formation of partnerships, economic developers are advised to favor development vehicles that promote collaboration between enterprises and growth companies. Innovative pioneers in this area already exist. The Nordic Innovation Accelerator (NIA)[11], for instance, runs a technology and business brokerage program that "invites corporations to bring their innovation needs to be served by a number of startup solutions." For startups, in turn, NIA's program provides "validation for their ideas and products and provides opportunities for funding and acquiring ready clientele." NIA has already successfully brokered partnerships between a number of Finnish start-ups and global enterprises such as Fortum and Veolia. A similar concept is applied by Vertical Accelerator[12], a broker of partnerships for growing health tech companies and large, multinational enterprises such as Samsung, Sonera and Ingram. In addition to the match-making service, Vertical Accelerator actively helps their small clients in developing their technologies and businesses to be ready for adoption by corporate partners.

Another useful vehicle for the promotion of cross-industrial partnerships is the support of world-class industrial and economic pilots that demonstrate the viability of emerging ecosystems on a believable scale. A great example of an ecosystem-wide demonstration is the Smart Energy Platform as currently launched in Åland. As the consortium behind the pilot states, "the target [of the pilot] is to create the world's most advanced flexible energy system of the future as a cleantech showcase in Åland, where a fossil free energy system and the whole value chain enabling different flexibilities simultaneously can be demonstrated."[13] The power of ecosystem-wide pilots is in that it already assembles a viable consortium – representative of the underlying industrial value chain – that can carry the momentum forward after the completion of the pilot. In a way, large enough pilots give rise to economically viable model ecosystems that can be seen as seedbeds for a larger ecosystem.

Finally, we argued that the fastest growing businesses in smart grid revolve around IT- and data-enabled service models (XaaS) that, given the progress in digitalization and machine-to-machine communication, are now available even to more conventional, engineering-driven component and systems manufacturers. The biggest drag on the proliferation of the XaaS model is the lack of a universal governance model for the ubiquitous network of the vast array of diverse and inherently incompatible IT-systems that digitally-enabled services run on. Most of the systems have been developed for a specific, stand-alone purpose and service. Interconnectivity between the systems has not been an integral nor desired feature at the time of their inception. In XaaS models, integration of IT-systems across entire value chains becomes key as data needs to flow along the chain of suppliers, clients and partners. Lacking a universal governance model, integration between systems today is a tedious undertaking, as connectivity needs to be established in a customized, non-scalable, case-by-case fashion.

Scaling of digitally-enabled businesses would see unprecedented rates if a unified governance standard for a network of systems could be established. History has shown that it is possible to introduce standards in a *de facto*, industry-induced fashion. It is a long, evolutionary road that is usually dominated by the large and often entails unproductive battles over who will set the standard that is adopted widely. On the other hand, history has also shown examples of active, centrally-lead standardization projects. These are a lot faster to set in place and, when designed properly, will not introduce market distortions that favor single stakeholders. Policy-

11 https://nordicinnovationaccelerator.com/

12 http://www.vertical.vc/

13 http://clicinnovation.fi/activity/smart-energy-platform/

makers and economic developers could take decisive action in promoting digital governance standards to pave the way for the quick emergence of cross-industrial service models that will not only help modern IT-businesses thrive but support incumbent, engineering-driven companies reposition their make-and-sell -based businesses models into scalable service models.

4 CASE STUDY 2 Smart Mobility – Increased safety, lower emissions, new jobs and improved social opportunities

Much in line with the evolution of Smart Grids, the emergence of the Smart Mobility ecosystem is driven by the various negative externalities that accompany the self-reinforcing, global megatrend of urbanization. The World Resources Institute (WRI)[14] claims that 70 percent of energy-related greenhouse gas emissions are produced in cities, and that developing cities, in particular, would contribute to the majority of traffic crashes that claim 1.2 million lives per year. The WRI explains that congested traffic costs the cities of Rio de Janeiro and São Paulo a combined $43 billion in 2013, a whopping 8 percent of the cities' GDP. The equivalent figure for Beijing, including costs related to air pollution, the Institute estimates at 7–15 percent of GDP. A study by the New Climate Economy[15], in turn, finds that Americans bear an extra cost of US$1 trillion related to urban sprawl.

To tackle these externalities, ICT-driven approaches to optimize available resources for moving people and goods in urban areas, in particular, provide for increased efficiency and safety "at a cost much lower than building new infrastructure from the ground up" (World Bank[16]). According to the US Department of Transportation[17], Intelligent Transportation Systems (ITS) – the purely technological aspect of Smart Mobility – can be defined as "the application of advanced information and communications technology to surface transportation in order to achieve enhanced safety and mobility while reducing the environmental impact of transportation. The addition of wireless communications offers a powerful and transformative opportunity to establish transportation connectivity that further enables cooperative systems and dynamic data exchange using a broad range of advanced systems and technologies." The European Telecommunications Standards Institute[18], ETSI, adds that ITS include "telematics and all types of communications in vehicles, between vehicles (e.g. car-to-car), and between vehicles and fixed locations (e.g. car-to-infrastructure). However, ITS are not restricted to Road Transport – they also include the use of information and communication technologies (ICT) for rail, water and air transport, including navigation systems."

The benefits are said to be wide-ranging. The European Commission[19] claims that ITS "are vital to increase safety and tackle Europe's growing emission and congestion problems" and that "the integration of existing technologies can create new services, [supporting] jobs and growth

14 www.wri.org/blog/2015/01/who-needs-cars-smart-mobility-can-make-cities-sustainable (last access Jun 2, 2016)

15 newclimateeconomy.net/content/release-urban-sprawl-costs-us-economy-more-1-trillion-year (last access Jun 2, 2016)

16 blogs.worldbank.org/transport/smart-mobility-developing-cities (last access Jun 2, 2016)

17 www.its.dot.gov/standards_strategic_plan/ (last access Jun 2, 2016)

18 www.etsi.org/technologies-clusters/technologies/intelligent-transport (last access Jun 2, 2016)

19 http://ec.europa.eu/transport/themes/its/index_en.htm

Figure 8 Toyota's smart mobility vision

Source: Toyota.

in the transport sector." Tass International[20], a Dutch technology development organization for the mobility sector, explains that a connected, smart mobility infrastructure will enable the reduction of the number of traffic accidents as well as the reduction of emissions and fuel consumption while improving traffic flow. In addition to economic and environmental benefits, Smart Mobility will also entail social improvements by providing low-income population vastly improved access to urban job markets and educational systems. WRI[21] provides an example with Medellín's (Colombia) Metrocable system that "has transformed what was once a day-long journey from the city's mountainous slums to its urban core into a 30-minute affair, increasing access to daily needs and empowering the city's most disadvantaged communities."

But how do these lofty concepts translate into reality? Toyota Motor Corporation provides an insightful vision of Smart Mobility in a real-life setting (Figure 8). Increased *safety* is enabled by real-time information sharing among vehicles, infrastructure and pedestrians. The information is used by automated collision prevention systems in vehicles to anticipate and actively avoid accidents. While sensor-based collision prevention systems already exist in contemporary vehicles, even more effective solutions will be based on communication between vehicles and the surrounding urban infrastructure.

Increased *comfort* and ease of use is the result of advanced communication interfaces between the driver and her vehicle that include verbal interaction and predictive information sharing on suggested routing, nearby social events, shopping opportunities, car maintenance and other personal points of interest that the vehicles AI will tailor to the driver's individual profile.

Heightened *convenience* comes with the decoupling of ownership and availability of unrestricted transportation. Interconnected public and crowd-sourced transportation (ride sharing, car sharing, etc.) systems are envisioned to render privately owned vehicles obsolete, as intelligent multimodal route guidance applications co-ordinate the availability and access to transportation services anywhere and at any time to anyone. The concept is also known as Mobility as a Service (MaaS). MaaS allows to forego heavy capital costs related to the ownership of cars and to incur only variable costs per use.

Finally, the progressing electrification of transportation systems has a direct impact on the ecological sustainability of traffic and other urban solutions. Electric vehicles not only reduce emissions in the direct urban environment but can be integrated into the larger Smart Grid ecosystem to serve as a temporary storage option for demand-response optimization purposes.

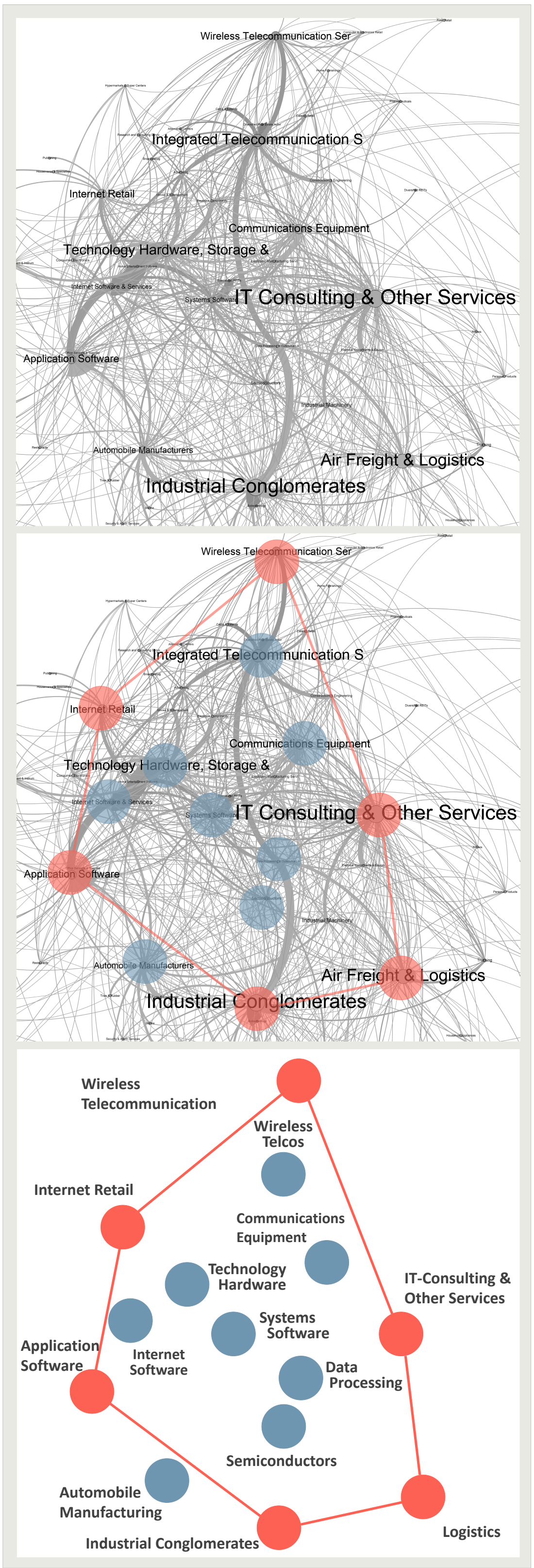
4.1 Smart Mobility already boasts an established industry structure

The network mapping analysis for Smart Mobility reveals established, cross-industrial value networks that speak of an ecosystem akin to Smart Grid (Figure 9). Unsurprisingly, the anchor industry foundation features legacy industries that are both manufacturing and capital intensive. These include (i) wireless telecommunications as the provider of the necessary wireless and mobile data transfer infrastructure, (ii) the transportation industry (logistics) that commands ground, marine and aerial fleet assets to provides transportation services, (iii) internet

20 https://www.tassinternational.com/safe-green-smart (last access OCT 22, 2015)

21 www.wri.org/blog/2015/01/who-needs-cars-smart-mobility-can-make-cities-sustainable (last access Jun 2, 2016)

Figure 9 Smart Mobility industry ecosystem



Maps by D. Assanis based on Bloomberg SPLC data.

retail as the sales platform and interface for purchasing mobility services in real-time on the go, (iv) the application software industry that develops mobile applications (e.g. route guides, navigation apps, and car sharing platforms) for users to navigate the interconnected mobility landscape, and technology component manufacturers, here "industrial conglomerates", as the providers of system components for the ecosystem's hardware infrastructure.

The catalyst industries, in turn, include the by now familiar software and IT-driven sectors such as systems software, data processing, and hardware, but now also feature sectors that in Smart Grid played the role of anchors. These are integrated telecommunications and communications equipment. It seems telecommunications operators are intent on leveraging their strong, direct link to consumers and established user interfaces to exploit opportunities in the mobility space. It is a brilliant strategy as Smart Mobility really is all about real-time information brokerage that, in contrast to Smart Grid, is easily delivered via mobile devices such as cell phones.

The role of car manufacturing in the Smart Mobility ecosystem is still somewhat uncertain. According to Ford Motor Company's projections, about 80 percent of the total value of ground vehicles will reside outside the physical vehicle within a decade if car manufacturers do not take measures to integrate the added value of Smart Mobility-related solutions into the vehicles. Ford itself has declared to pursue a re-positioning strategy that will see a shift away from the drive train and chassis to the digital, interconnected dashboard as the most valuable element in a vehicle. Ford is on route to transform its identity from a car company towards a technology company. If Ford's case is to be taken as a signal of a trend that will define the future of car manufacturing, then the sector might very well serve the role of integrator in the budding Smart Mobility ecosystem. It might well become a catalyst sector, fighting for market share with telecommunications.

In summary we can state that there is clear evidence of industrial momentum in Smart Mobility. How well, then, do Smart Mobility businesses fare in the value capture and investment grade analyses? How well are they able to take advantage of the emerging opportunities in the

Table 2 The Finnish Smart Mobility industry performance in numbers

Metric	All (n=107)	Start-ups (n=16)	SMEs (n=50)	Enterprises (n=37)
Personnel	425,2	3,5 *	47,3 *	1079,0 *
Value added (€ mill.)	43,3	0,2 *	4,2 *	123,8 *
Turnover (€ mill.)	352,0	1,0 *	24,5 *	927,2 *
EBITDA %	-14,3	-59,7	-5,7	-11,8
Equity ratio %	24,6	12,5	12,3 *	45,3 *
Current ratio %	2,1	2,1	2,0	2,2
ROI %	5,0	-7,6	4,4	8,8
EBIT %	-19,9	-81,5 *	-11,6	-12,9
Quick ratio %	1,8	1,8	1,7	2,1
ROA %	3,3	-7,4 *	3,6	5,7
Net profit %	-17,3	-85,5 *	-11,2	-5,4
Alpha rating (99-7)	22,1	39,7 *	23,5	15,7 *

ecosystem? The descriptives in Table 2[22] provide for key financial indicators on pure financial performance. The results go hand in hand with those distilled from the Smart Grid ecosystem: Large, well-established companies outperform their smaller competition in every aspect except the EBITDA margin. Also, the overall poor profitability across the population continues to cast worrisome shadows on the long-term viability of the sector (for more detail see Kotiranta et al., 2015). Again, we turn to more fundamental analyses on the future potential of Smart Mobility as an economic growth sector.

4.2 Capital intensive business models compromise excellent value capture position of large companies

Contrasting the results of value capture and investability analyses of Smart Mobility to those from the Smart Grid industry provides for interesting insights (Figure 10). Unlike in the Smart Grid ecosystem, there seem to be fairly pronounced differences in value capture capabilities between large incumbent companies and their smaller competition. Enterprises are clearly better positioned to exploit Smart Mobility opportunities. The majority, if not all, of the assessed enterprises reside in the upper quadrants of the value capture matrix (*left* panel), indicating that they command over rather specialized, leverageable capabilities for the Smart Mobility business.

Figure 11 gives clues as to what these capabilities relate to: Large companies beat their smaller peers in both the *difficulty to replicate* organizational core capabilities and industry *connectivity*. As discussed earlier, low replicability indicates strong intellectual property protection strategies as well as experienced and capable management teams that can bring to bear their skillsets in exploiting the emerging business ecosystem. This human capital is tacit in nature and therefore hard to imitate.

High *connectivity* to relevant industry partners, in turn, provides access to assets and capabilities *outside* the firm that it still needs for the production of goods and services in the new ecosystem. The exceptionally high connectivity – decisively higher than the connectivity of enterprises in the Smart Grid ecosystem – implies (i) *existing* partnerships in the form of contracts, joint ventures or other formal agreements and (ii) *capabilities to form new partnerships* via leveraging the management team's long-term experience in the relevant industry sectors as well as exploiting existing partnerships with third parties – such as consulting offices and economic development offices – that are well-connected in the new ecosystem.

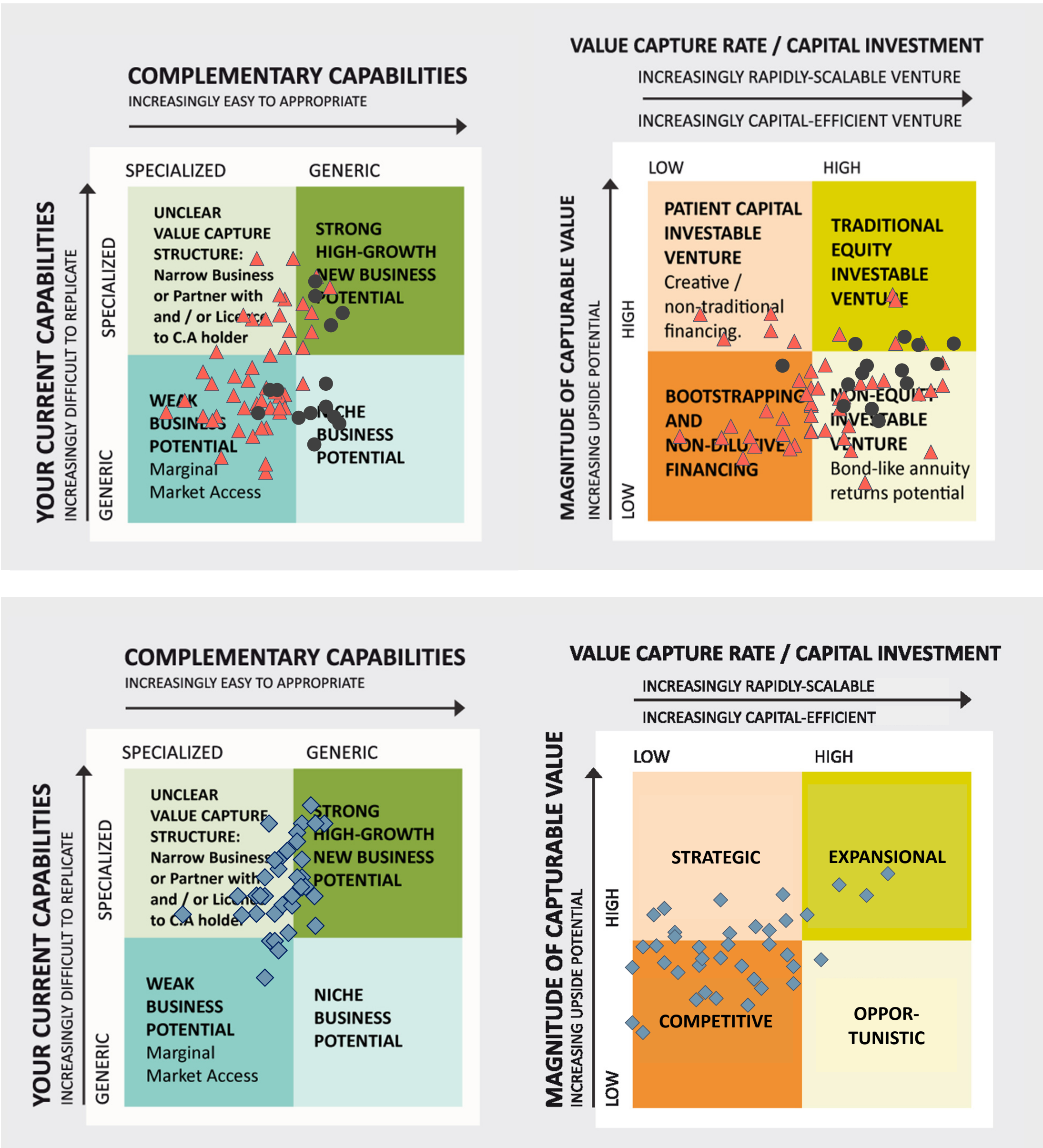
The position of strength in the ecosystem is further corroborated by low *dependency* on third party connections. Companies seem to have abundant options with regard to partnerships and needed third party assets, which helps in retaining bargaining power and strong value capture capabilities.

The analyses reveal only one weakness that keeps large companies from populating the high-growth quadrant: *Low leverageability* of partnerships – the very same flaw that plagues companies in the Smart Grid ecosystem – undermines the companies' ability to exploit their high connectivity for effective market penetration. The existing partnerships are not necessarily the

[22] Results are winsored (2.5%) arithmetic averages. Asterisks signify statistically significant, t-tested results.

most relevant for or most capable of providing market exposure. As is the case in the Smart Grid ecosystem, low leverageability might well be an indication of Smart Mobility's immaturity as an industry and market place rather than a sign of a weakness on part of companies. It is challenging to find channel partners to access a market if there is next to no market to start with. Once the market matures, however, their excellent connectivity and low dependency give large companies a formidable vantage point to exploit opportunities in Smart Mobility.

Figure 10 Value capture (left) and investment grade (right) analysis for emerging businesses (grey), SMEs in business longer than 5 years (red), and large enterprises (blue) active in or positioning for Smart Mobility LOBs



If the value capture position of large companies seems convincing, the *investment grade* of opportunities in the Smart Mobility ecosystem is poor (Figure 10, right panel). Large companies are to be found in the two left most quadrants of the investment grade matrix, which indicates that the intended strategies to conquer the Smart Mobility space only allow for low to mediocre speed of returns. Figure 11 (bottom panel) provides grounds for the interpretation, showing poor results for both the *scalability* and *capital efficiency* of applied business models. The companies suffer from the very same syndrome as their peers in the Smart Grid ecosystem: They enter the new ecosystem with *conventional* strategies, trusting approaches they have successfully employed in their legacy businesses. They are manufacturing-centric and their labor-intensive sales models incompatible with digitalized, autonomous service platforms that will capture most of the revenues in the growing smart layers of the emerging ecosystem. It is a pity especially because the results for *diversification*, an indicator for the volume of identified market opportunities, are extremely promising (81% average); even more promising than for enterprises in the Smart Grid ecosystem.

4.3 Smart Mobility start-ups and SMEs show weaker value capture capabilities but better investability than their Smart Grid peers

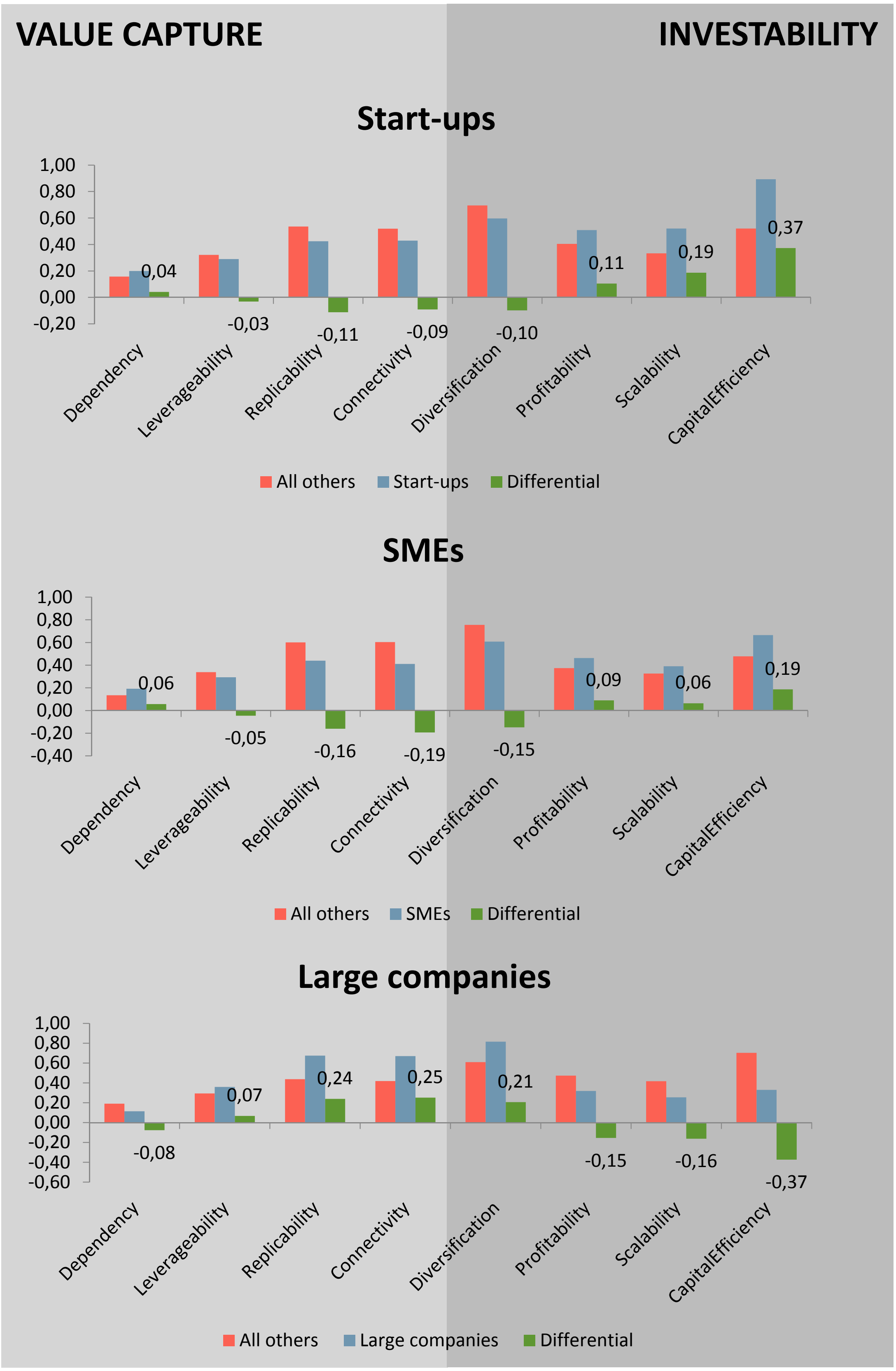
The value capture capabilities of Smart Mobility start-ups are, by and large, comparable to those of their peers in Smart Grid. While a small number of individual companies show promise of high growth and hold a strong value capture position in their respective value chains, many have to be content with niche business potential (Figure 10, *left* panel).

Like their Smart Grid peers, Mobility start-ups have *poor leverage* over their market channel partners. An additional weakness is relatively *high replicability*. At 42 percent, their *average* Keystone score for the difficulty to replicate key value capture capabilities is 14 percentage points lower than in the case of their Smart Grid benchmark (Figure 11, upper left panel). The threat of imitation and the ease of acquiring the same assets the companies employ to generate value compromises the amount of value Smart Mobility start-ups can retain. Small and medium-sized companies fare even worse. Not only is their average *replicability* score much lower than that of Smart Grid SMEs, but their performance is weaker with regard to almost every other value capture metric with the exception of *dependency*. *Connectivity*, especially, is weaker by eight percentage points.

In contrast, Smart Mobility start-ups and SMEs show better performance in terms of *investability* than their peers in the Smart Grid ecosystem (Figure 11, *right* panel). Start-ups, in particular, outshine the benchmark in every *investability* metric. With an impressive average *capital efficiency* score of 89 percent, a *diversification* score of 60 percent and both remaining metrics above 50 percent, the *average* Smart Mobility start-up would be a clear candidate for high-growth equity investment. This is an excellent result:

The companies have identified both abundant and lucrative market opportunities (high *diversification* and *profitability* scores), and have developed the right business models to quickly access and exploit them (high *capital efficiency* and *scalability* scores). The question is what is stopping them? Why do we not see most of the companies pictured in the upper right corner of the investment grade matrix in Figure 10?

Figure 11 Value capture and investment grade drivers of the Finnish smart mobility sector



As was the case in Smart Grid, the culprit is the companies' poor value capture position in the ecosystem. A weak position affects the ability to retain created value and, thereby, has a strongly compromising effect on the upside potential a company can tap into. In a poor value capture position much of the potential is captured by partners and the competition. Investors and financial markets take this into account and correct the investability assessments accordingly. Compared to start-ups, SMEs suffer additionally because they seem to employ less scalable and, ultimately, also less profitable business models. Scalability and profitability have an effect on both the upside potential of a business and the speed at which returns can be generated.

4.4 Could symbiotic relationships be the way forward for enterprises and SMEs in the Smart Mobility space?

What insights can we draw from the results? Clearly, many of the takeaways drawn from the Smart Grid ecosystem apply also here. Both ecosystems show proof of existing industrial momentum; they are also both characterized by an anchor-catalyst industry structure, the emergence of which is driven by data- and software-driven, scalable businesses that lean on the infrastructure provided by large, incumbent industry. To avoid tautology, we focus on the differences between the ecosystems for drawing additional insights.

One of the most striking findings is that large enterprises seem to be exceptionally well positioned to capture value from the Smart Mobility ecosystem. They are endowed with the essential assets – both tangible and intangible – to be independent of other actors in the ecosystem; they protect these assets well, and have established effective channels to access the relevant markets. Indeed, large enterprises do not only beat their Smart Grid peers in value capture capabilities but are also clearly ahead of their smaller competitors – start-ups and SMEs – in the Mobility space. So, what is to stop them from establishing a dominant position in Smart Mobility and to drive and accelerate its development as resourceful actors?

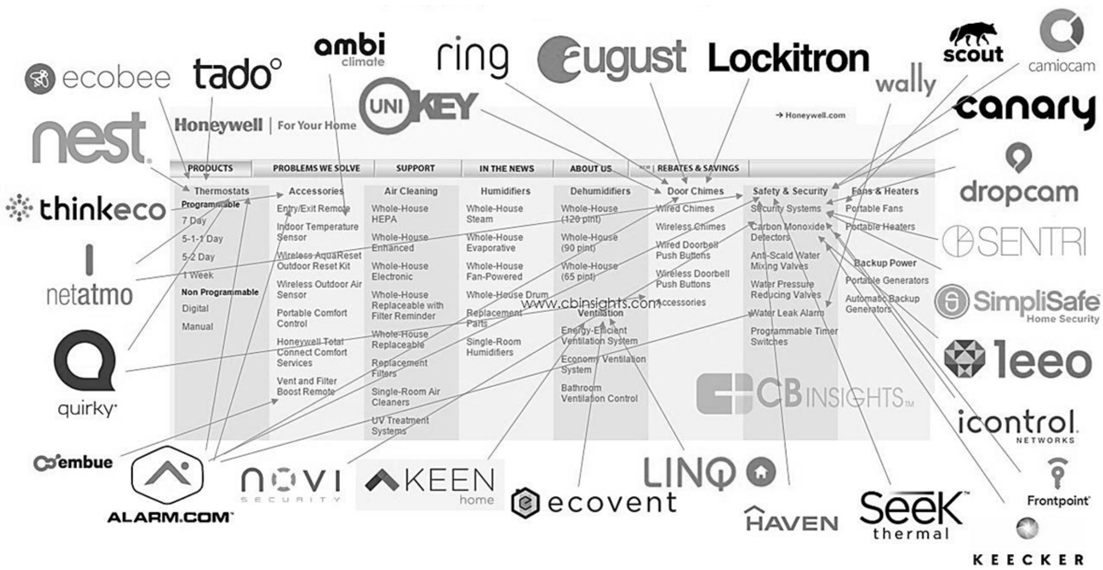
The reason lies in the strategies and business models enterprises have adopted to explore opportunities in Smart Mobility. Bound by legacy business trajectories, enterprises rely on their incumbent, capital-intensive and infrastructure-heavy approaches to explore the new ecosystem. These approaches many times imply high-volume but low-margined business models. These, in turn, translate into low expected profitability and long lags between initial investments and the respective returns. At worst, the companies continue to pursue commodity business models, such as selling data transfer by the megabyte, or transportation by the kilogram or distance. Therefore, to profit from their excellent asset base, enterprises need to redefine there role in the ecosystem and adopt aggressively scalable, capital efficient business models such as those found in the digitalized Xaas domain.

Their smaller competition knows how to do it: Start-ups and SMEs have a relatively weak value capture position but apply excellent, high-growth business models. Their problem is, however, that acquiring the much needed fundamental assets in an attempt to improve their weak position in value chains is a lot harder than merely re-defining strategy and business models. Partnering with incumbents for resources – starting off from such a weak position as it is – might expose SMEs to the danger of being marginalized even further.

That being said, the incumbents do have what SMEs need and cooperation might very well be the only viable option to gain access to markets.

With skill, a viable alternative strategy is to scout those little niches in the capability base of incumbents that they still lack and to exploit the weakness. Specializing in the niches can be a viable strategy to generate revenue for fueling growth and building up required assets to strengthen value capture capabilities. This has been evidenced in the 3rd wave of unbundling, a recent phenomenon that sees small service businesses pick apart the fringes of the generic service offering of incumbents, each focusing on where the individual company's comparative advantage is. Figure 12 lucidly illustrates the phenomenon by way of showing how "startups can successfully take on titans in the home including Philips and Honeywell by attacking them at a product/service level," as CBInsights[23] puts it.

Figure 12 Start-ups follow niche strategies to compete against incumbent Honeywell



Source: CBInsights.

What can incumbents do to dodge the fate of being eaten alive by a school of ferocious piranhas? There are to evident avenues:

Pursuing the first implies an active, if selective, partnering strategy either via contractual relationships or more robust vehicles such as joint ventures. From the incumbent's perspective partnering in any mode exploits the dependency of the smaller partners on the incumbent's assets. The aim is to pursue either (i) a *learn-and-let-go strategy* - i.e. to adopt and adapt agile business models to the incumbents business as taught by the smaller, innovative partners and, eventually, beat them in their own game – or (ii) an *acquisition strategy* that advocates integrating promising growth companies as new lines of business via acquisitions.

23 https://www.cbinsights.com/blog/disrupting-honeywell-startups/

The second avenue requires paradigm shift -level changes in corporate strategy and leans heavily on the capabilities the digital revolution is promising to provide: The *platform strategy* advocates incumbents to tactically surrender entire lines of business to up-and-coming growth companies that have the competitive edge in the afore mentioned niche businesses. Then, incumbents leverage their highly coveted assets to become platforms for growth companies, providing them with standardized development toolkits, access to the consumer interface, payment interface, transactional back-office functionality and other key resources to develop, launch and run their businesses. In Smart Mobility, one of the key roles of platform providers will be the seamless integration of the various services developed by independent growth companies that populate the platforms. After all, seamless integration of multi-modal private and public transportation is what defines Smart Mobility.

The first question that comes to mind when thinking about the platform business model is how to monetize it. An early and established example of a successful platform business model is that of Apple's AppStore. Apple simply takes a cut of every transaction concluded on its AppStore platform; a whopping 30% to be exact. The platform strategy is attractive because it provides benefits to both incumbents and growth companies alike: Start-ups and SMEs gain access to the ecosystem-specific assets such as capital-intensive infrastructure and market channels without having to make excessive investments. Incumbents, in turn, can profit from the scalable and fast-growing businesses of growth companies by taking a cut – basically a service fee for running the platform – without having to adopt new business models that do not necessarily fit their organizational or capital structures.

4.5 Establishment of standards for system interconnectivity high priority for economic developers

Economic developers can help in clearing the playing field from obstacles. Smart Mobility, even more so than Smart Grid, is all about real-time coordination of mobility assets, infrastructure and human beings that currently are using a multitude of systems and related standards that do not communicate across system borders. Standardization here is all the more important than in Smart Grid because adding the masses of consumers, their mobile devices and vehicles as well as the mind-boggling amount of transactions they initiate between involved systems makes integration and coordination a lot more complex. Interconnectivity of systems is therefore paramount for scaling the Smart Mobility ecosystem. Large incumbent companies intent on building platforms for Smart Mobility can do only so much in dynamic economies. The emergence of too many competing standards can be a real drag on the evolution and growth of Smart Mobility as a promising ecosystem. Economic developers could promote such growth by aggressively pushing for universal standards in inter-system connectivity via legislative measures.

5 CASE STUDY 3
Green Chemistry – A Bioeconomy sector in need of policy intervention

To conclude this study and to benchmark the two "smart" ecosystems, we take a look at a very different, yet equally prospective industry space, the Bioeconomy.

The last few years have witnessed an exponential growth in both political and commercial momentum for the concept of the Bioeconomy. The commitment to designing and supporting policies for the implementation of the concept runs high; institutions including national governments, the EU and the OECD have laid out long-term strategies to harness the progress in biological resource technologies for sustainable economic growth and improvements in physical and socio-economic welfare (see Box 1).

Box 1 Bioeconomy – A sample of definitions

"The bioeconomy comprises those parts of the economy that use renewable biological resources from land and sea – such as crops, forests, fish, animals and micro-organisms – to produce food, materials and energy. It is an essential alternative to the dangers and limitations of our current fossil-based economy and can be considered as the next wave in our economic development. It provides major opportunities for innovation, jobs and growth and as such will help to reindustrialise Europe."

European Commission, Research & Innovation

From a broad economic perspective, the bioeconomy refers to the set of economic activities relating to the invention, development, production and use of biological products and processes. […] The application of biotechnology to primary production, health and industry could result in an emerging "bioeconomy" where biotechnology contributes to a significant share of economic output. The bioeconomy in 2030 is likely to involve three elements: advanced knowledge of genes and complex cell processes, renewable biomass, and the integration of biotechnology applications across sectors.

The Bioeconomy to 2030: designing a policy agenda.
International Futures Programme, OECD.

Finnish economic developers have been at the forefront of strategy design and already have something to show for it. Only as recently as 2014 did Finland rank second in Global Cleantech Innovation Index (WWF & Cleantech Group 2014). Led by the Ministry for Employment and the Economy, Finland has crafted national Bioeconomy strategies which are to be implemented by national and regional development agencies via various technology programs, such as the new Bioeconomy Development and Growth Programme run by Tekes, the Finnish Funding Agency for Innovation. Efforts between agencies are effectively coordinated via the Team Finland[24] consortium that comprises central ministries and economic development agencies in the country.

Box 2 Bioeconomy and clean solutions

1. Towards carbon-free, clean and renewable energy cost-efficiently
2. Wood on the move and new products from forests
3. Breakthrough of a circular economy, getting waters into good condition
4. Finnish food production will be profitable, trade balance on the rise
5. Nature policy based on trust and fair means

Source: Finnish Government.

[24] http://team.finland.fi/en/team-finland-in-brief (last visited 4.1.2016)

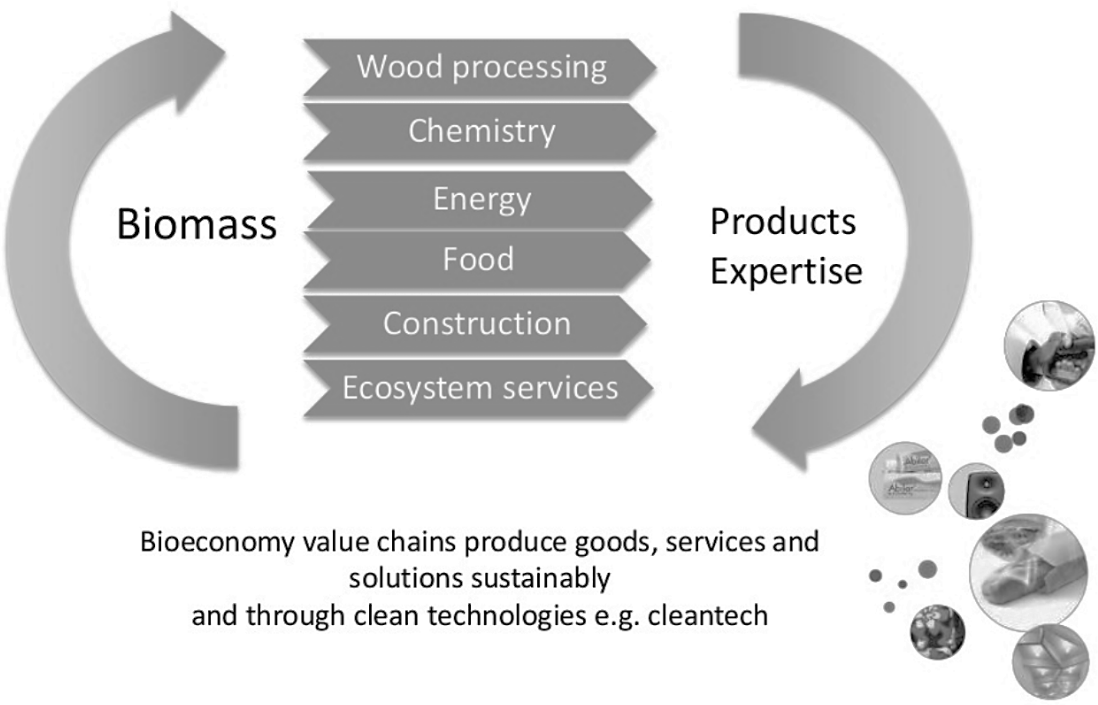
5.1 Finnish government committed to promotion of Bioeconomy

The strongest of commitments, however, has been made by the Finnish government itself. In a push to turn around a lackluster economy, the government has declared the "Bioeconomy and clean solutions" one of its five strategic priorities (see Box 2)[25]. In the spirit of the various existing definitions of the Bioeconomy, the Finnish Government defines the concept very broadly, including economic sectors such as energy, forestry and paper, natural resource management, and food and feeds.

Figure 13 portrays the circular economy envisioned to constitute the industrial structure of the Bioeconomy. The strategy is broad and rests on the implicit assumption that the conventional industrial pillars of the Finnish industry will interconnect via new value chain segments and integrate innovations in biological materials to provide new economic value added in the form of sustainable products and process technologies.

The viability of the strategy, then, hinges on whether there is tangible evidence of new inter-industry value chains being formed. This evidence would suggest that industries and markets have picked up on the promises of the Bioeconomy and started to adapt to and build out bio-based processes. The question about industrial momentum is pivotal because creating an entire industry ecosystem from scratch – on political momentum and resources alone – is an extremely costly, inefficient and multi-generational undertaking.

Figure 13 Bioeconomy value chains



Source: TEM.

[25] valtioneuvosto.fi/hallitusohjelman-toteutus/biotalous (Last visited Jun 2, 2016)

Government policies indeed need to be designed by leveraging promising weak signals from the economy, to reasonably assure the viability of their outcome or impact. Given the long-lasting global excitement around concepts such as Cleantech and Finland's economic roots in natural resources and related expertise, it is easy to believe in a Finnish comparative advantage as grounds for industrial policy.

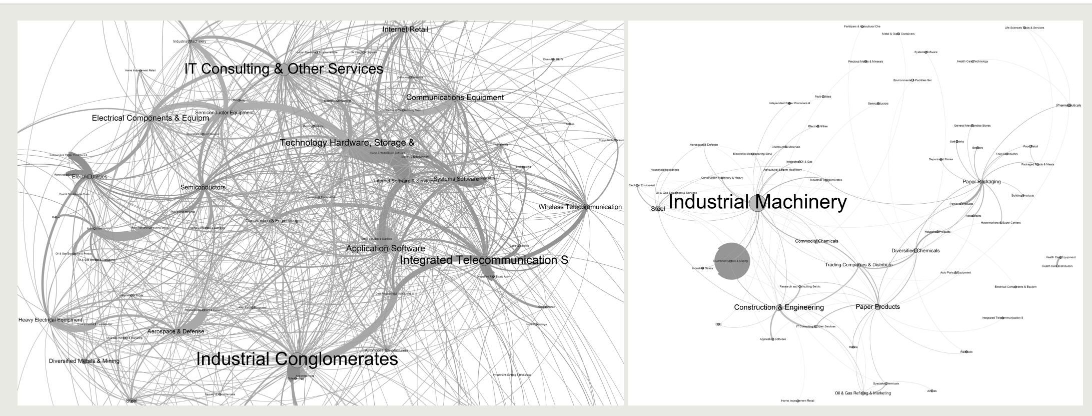
5.2 No transactional evidence of bioeconomy on industry level

The evidence from economic data, however, is sobering. Company data[26] on inter-industry transactions reveal that the transactional connectivity, i.e. the existing value chain structure in the alleged Bioeconomy is weak at best (Figure 14, *right* panel). There is no evidence of a (circular) value system structure that is envisioned in Figure 13. Compared with other inter-industrial cleantech ecosystems – such as the well-established Smart Grid sector (Figure 14, *left* panel) – the focal industry sectors of the Bioeconomy seem to remain transactionally isolated in their conventional legacy value chains.[27]

What could be the problem? Maybe the all-encompassing bird's eye view on the *entire* Bioeconomy is too cursory an approach to reveal in-depth economic structures? One could ask whether evidence from economic actors in Bioeconomy *sub-sectors* provides more detail of their specific value chain relationships.

For instance, a look at Green Chemistry, an emerging industrial trend that seeks to substitute hazardous and fossil-based raw materials for sustainable and renewable resources such as bio-

Figure 14 The robustness of value chain structures in comparison: Smart Grid vs. Bioeconomy

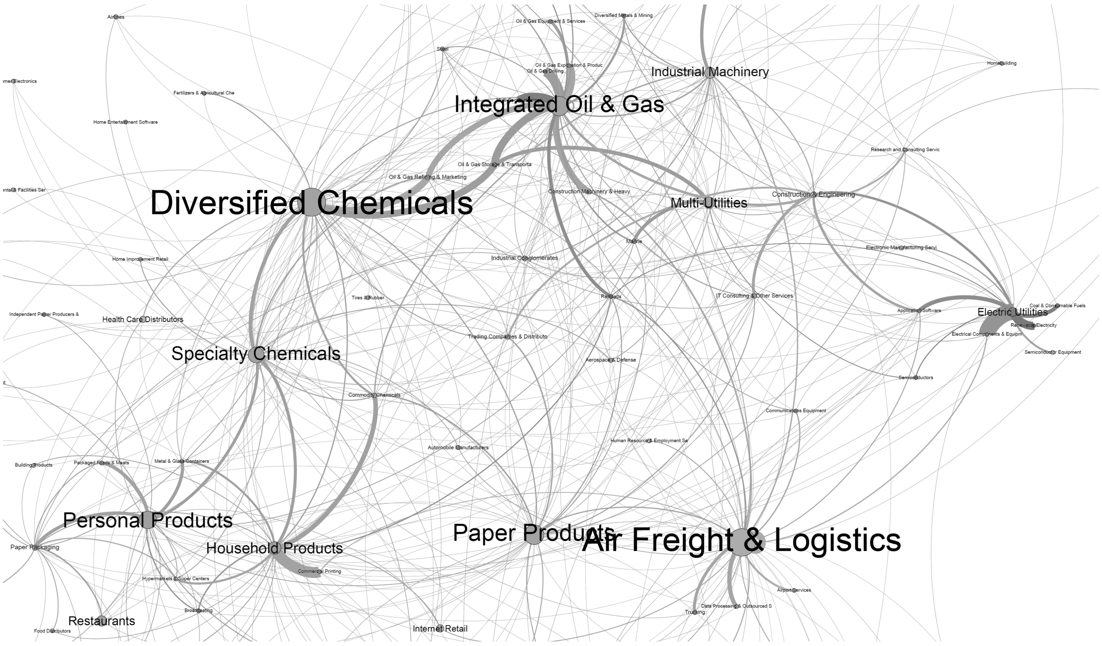


Maps by D. Assanis.

26 The Bloomberg SPLC Database provides company-level data on supplier-client relationships and their bi-directional monetary exposures. The lines, called "edges", between the various sectors in Figure 2 represent *existing transactional business relationships between companies in these sectors*. The thicker the edge is, the higher is the financial exposure between the sectors. Using the companies' industry classification codes, the data was aggregated onto the industry sector level. Data extracted in July 2015.

27 The network maps displayed in this brief have been built out based on a Finnish company population. However, no geographical limits have been imposed on the business partners of the companies in said population, respecting the fact that many – if not most – business relationships in the global economy are cross-border relationships. Therefore, the maps displayed here by no means represent exclusively domestic business ecosystems only.

Figure 15 Green Chemistry value chains



Maps by D. Assanis.

mass, provides for more promising results (Figure 15). Robust transactional connectivity between a number of different industry sectors is clearly evident.[28]

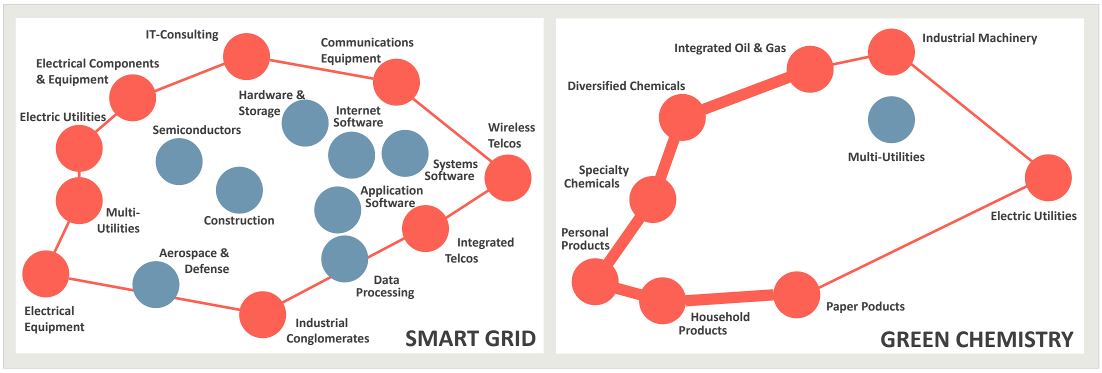
An abstraction of the same map (Figure 16, *right* panel) reveals a multi-industry structure that encompasses sectors such as chemicals, integrated oil and gas, paper, household products, industrial machinery and electric utilities. Surely this should be strong enough empirical evidence of a circular economy? Unfortunately, this is a premature conclusion. Comparing the structures of the Green Chemistry ecosystem to those of the familiar benchmark, Smart Grid (Figure 16, *left* panel), reveals decisive structural weaknesses in the Green Chemistry ecosystem.

5.3 Evidence shows weak signals of incipient Green Chemistry value chains

Unlike the Smart Grid ecosystem, the Green Chemistry ecosystem *almost entirely lacks meaningful catalyst industry sectors*. There are *only few* existing value chain structures between sectors that provide "green resources" – such as the biomass generating paper industry – and industries that would use them as sustainable inputs. On the contrary, the structure displayed in Figure 16 (*right* panel) represents the classical value chain structure of the chemical industry,

28 The careful reader might wonder how a sub-sector (here Green Chemistry) of a larger ecosystem (here the Bioecon-omy) can display more robust connectivity than the ecosystem itself. The reason is that the map of the Bioeconomy in Fig. 2 only builds on the specific industrial sectors mentioned in the original government strategy briefs describing the Bioeconomy. In the case of Green Chemistry, we use a broader and more detailed set of industry sectors that are argued to contribute to the ecosystem. The differences in connectivity between the two approaches already shows that, to gain any feasible insights on the viability of an ecosystem, it is necessary to focus on clearly defined, thematic industry value systems.

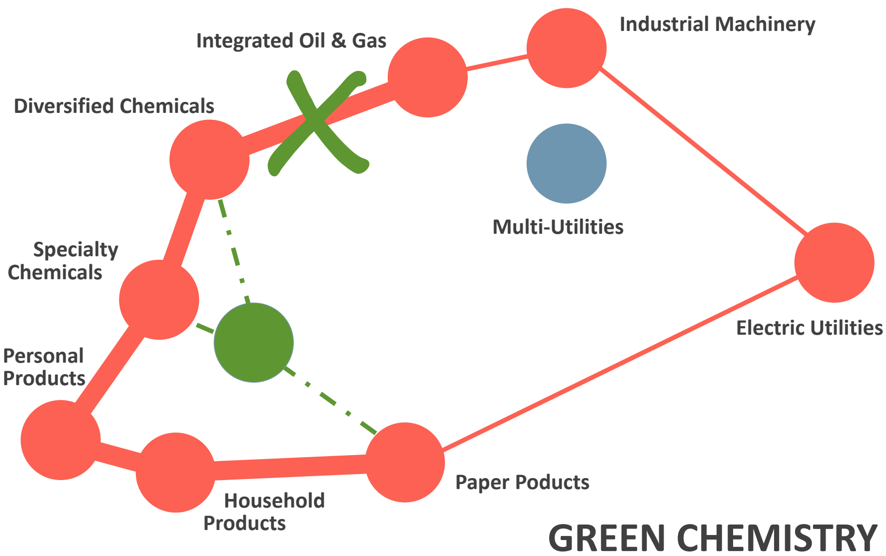
Figure 16 Abstractions of value chain structures in comparison: Smart Grid vs. Green Chemistry



consisting of its supplier relationships in the fossil raw materials industry, on the one hand, and its client relationships in the household product industry on the other. What we see in the picture is the industry's structure as it has existed for the past few decades already. In short, there is no indication of encouraging trends towards a new, biomass-based circular economy.

That being said, a detailed examination of the map displayed in Figure 17 reveals that there are weak first signals of incipient connections between the paper and chemicals sectors. The three sectors are bridged by a potential catalyst, the *commodity chemicals* sector (Figure 17, green edges). According to the data at hand, this link is still very weak but could be early indication of an alternative, sustainable, biomass-based resource sourcing strategy of the chemicals sector. Evidence that this signal is at work in the real stocks and flows of the economy is based on investment by major chemical giants such as BASF and the Dow Chemical Company in entrepreneurial startups that have developed processes to generate new cellulose-based building blocks as input raw materials for chemical production.

Figure 17 Incipient value chains between paper and chemicals sectors



5.3 Promotion of bioeconomy only viable as long-term, patient strategy with marginal short-term economic impact

What is to be made of the results? Clearly, the existing industrial structures do not promise short-term growth. The necessary circular value chain structures need to be developed first before the ecosystem can be expected to contribute to economic growth on any relevant scale. From emerging industry pilots in the Green Chemistry space – such as the number of rising bio-energy plants in Finland – we know that opportunities to harness the country's natural resources are seriously being probed. What is not known, however, is whether they will catalyze the much sought after economic growth.

Here, the crucial question is whether renewables-based materials merely substitute for petrochemical raw materials in the economic plumbing system of the conventional industry structure, on the one hand, or whether they actually entail the emergence of entirely new economic activity, perhaps even the emergence of entirely new industry sectors, on the other. If the former scenario turns out to be the case, the best possible outcome from an economic point of view is an increase in competitiveness – fueled by a global drive towards industrial sustainability – of *the existing industry* at best. It could provide fading, incumbent industry sectors with enough ammunition to stay in the game. This, of course, is an admirable outcome in and by itself, especially if it helps to sustain existing jobs.

Box 3 Key insights
- System-level evidence of industrial momentum in the larger Bioeconomy is weak.
- Economic policy promoting the Bioeconomy is not expected to generate short-term growth and must be patient.
- Moving to a bio-mass based economy might require policy intervention to break strong vested links between petro chemicals and industries using fossil raw materials in their processes.
- Other emerging ecosystems in the larger cleantech space, such as Smart Grid or Smart Mobility, already show clear industrial momentum.

For real economic growth, i.e. new industrial activity and job creation, however, only true industrial renewal is sufficient. The incipient structures between biomass-producing sectors and the chemicals industry could be a seedling of such activity. New companies are being formed that refine biomass into a form exploitable by the chemicals industry. The biggest threat to the emergence of more robust links between biomass producing sectors and chemicals are the long-lived, vested interests between the fossil raw materials sector and the chemicals industry. Evidence from Europe's largest chemical megacluster – the Antwerp-Ruhr-Rhein axis – is not encouraging. The strength and low cost supply of incumbent fossil fuel industries is at this time relegating bio-based materials to a niche substitute product, rather than displacing existing supply chains.

For an alternative, more sustainable structure to flourish and succeed, this strong link needs to be broken (see red cross in Figure 17). This is a classic case for regulatory government intervention, justified by the environmentally negative externalities that entail the use of fossil raw materials.

In accordance with classical literature (see for example Hamilton, 1791), one can argue that nurturing infant industries – such as Green Chemistry – is exactly what economic development policies are meant for. If such a strategy is chosen, however, the decision needs to be made with the awareness that, in case of the Bioeconomy in particular, it will not be a quick fix to an urgent problem such as the lackluster Finnish economy. Building an entire industrial ecosystem with its complex web of value chains is viable only as a patient long-term strategy that will far exceed the limits of any single term of office of any government. Beyond single pilots, there is currently limited market validation for industrial momentum in the alleged Bioeconomy.

The above insights presented themselves based on the industry structure analysis alone. To gauge the competitiveness of actual companies active in Green Chemistry more in-depth, we need to run them through the same value capture and investibility analyses as the companies in both of the "smart" ecosystems.

5.4 Green Chemistry – A biotechnology industry model where innovators partner with incumbents for channels and capital

Perhaps the most challenging aspect of assessing the green chemistry industry is that green chemistry is less a description of a discrete industrial segment than it is a way of carrying out industrial activity, from design to manufacturing.

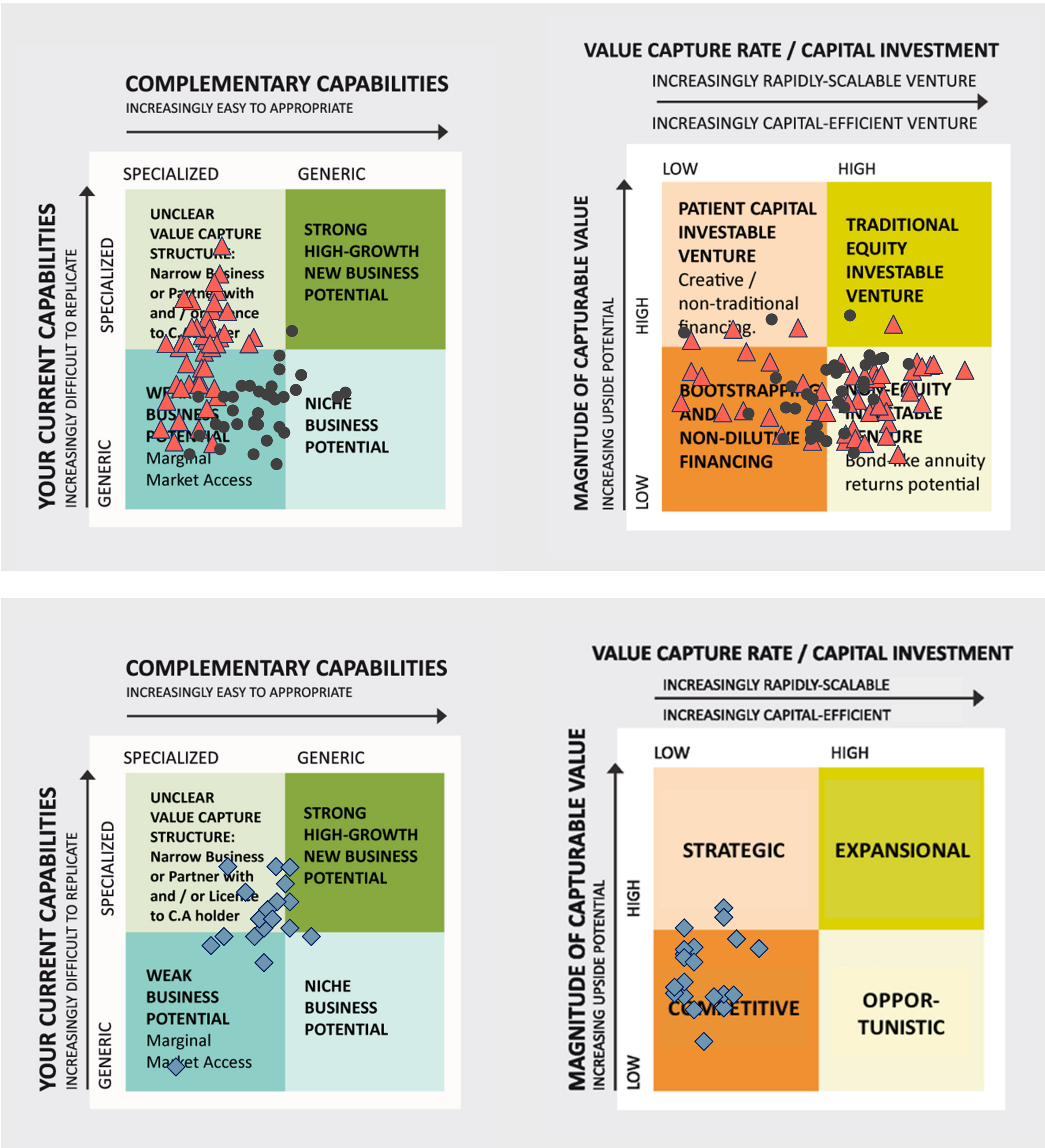
According to Pike Research (2011), "Green chemical industry players run the gamut from vast multinationals that have been in operation for over a century to tiny startups. Much of the bio-based segment, which perhaps has the greatest long-term potential to revolutionize the chemical industry, is nascent. Technologies are just a few steps beyond the laboratory, and production facilities are a few years from reaching their modest full production levels. The bio-based segment of the market, excluding biofuels, is liable to grow slowly because of challenges with issues of scale. Also, in the chemicals and materials business, the adoption cycle often requires long lags for extensive customer testing before new products are introduced."

Informed by the ecosystem mapping exercise, we thus explored the companies and industry sectors that participate in the value chains of the various activities geared towards building out the material sourcing, chemical manufacturing, sales and integration into consumer products. A total of 61 companies, from a registry base of over 100 companies, were analyzed for value capture and investment grade (Figure 18).

The results indicate that, as compared to smart grid and smart mobility, most startups and SMEs occupy the 'weak business potential' quadrant, some exceptions notwithstanding. This could plausibly be attributed to the immature markets in this space. Without external policy drivers incentivizing the integration of green chemistries, and without internal efficiency drivers in the industry (see the previous chapter), the opportunities for new market access are limited, except through partnerships with large enterprises. This segment of the economy fares better in the value capture space, with most companies in the partnership and license area, only straddling new growth potential.

In the investment grade analysis, the business and revenue models of 90% of startups and SMEs places them in the lower two quadrants, with the overwhelming majority in the debt financeable quadrant. The implication is that it can be expected that cash-flow driven businesses will be built, rather than high growth platform firms with significant market and revenue diversification opportunities. The large enterprises fare no better: Close to none of the analyzed companies are currently engaged – or have committed resources to – the green chemistry industry.

Figure 18 **Value capture (left) and investment grade (right) analysis for emerging businesses (grey), SMEs in business longer than 5 years (red), and large enter prises (blue) active in or positioning for Green Chemistry LOBs**



5.5 High dependency, low leveragability, and poor scalability explain the generally weak investment grade positioning of all three company sizes

As is the case with many nascent markets, the green chemical market is expected to grow through several stages: a profusion of small companies based on exciting technologies will gradually coalesce, through failures, acquisitions, and mergers, into a functioning ecosystem. Many of these small companies will likely choose to follow a model that is common in the biotechnology industry, whereby small, innovative companies partner with industry incumbents to obtain capital and distribution channels. Established companies have the luxury of choice. They can either establish their own green operations, or watch the startups as they develop and acquire those that are the best fit for their own businesses once some of the technology and market risk has been wrung out.

The results indicate that the technical advantage of startups and SMEs cannot be effectively leveraged in an industry where most large players are very diversified and tend to be dominated by fossil fuel raw materials. This was borne out in the green chemistry ecosystem analyses earlier as well. Most financial transactions occur between the oil companies and refiners on the one hand, and specialty/diversified chemicals on the other hand, to supply the various consumer goods industries. These include personal care and cleaning products, baby products, apparel and footwear, healthcare, electronics, building materials and furnishings. According to a recent report from TruCost (2015), enhanced value chain collaborations are required to accelerate safer chemistry. This points to the immature linkages, as we saw in the financial network map earlier, one-project-at-a-time market development, and thus lack of leverage for startups and SMEs.

5.6 Large enterprises are characterized by limited leverage, high dependencies and low scalability

The uncertainty of green policies and volatile petroleum prices are to blame. While regulatory regimes at the federal level in the United States do not appear likely to become increasingly stringent soon, several states have imposed strict new regulations on hazardous chemicals, as has the European Union, by way of promulgation of the REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) program. Enacted in 2007, it has been phased in over the next ten years, and aims to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances, particularly when better alternatives are available. The phase in has been slow and the industry response is largely voluntary[29].

On the other hand, consumers are becoming increasingly aware of the potential effects of the chemicals used to produce common materials and are demanding green alternatives. Companies are being forced to meet not only end-user demand, but also the demands of powerful retailers, which can dictate product specifications to their suppliers by virtue of their vast sales. But the low petroleum prices – crucial both as a source of process energy and as a feedstock for many chemical processes – have slowed down scaling of and investment in finding alternative, renewable feedstocks for key chemical products and intermediates.

[29] European Commission (2007). Available at http://ec.europa.eu/environment/chemicals/reach/reach_en.htm. Last access June 22. 2016.

5.7 Green Chemistry start-ups and SMEs show strong differentiation and connectivity in the industry

Despite these mixed market signals, there are encouraging trends in the analysis of the companies that appear to support the stages of development of this emerging industry. Taking a more detailed look at the KeyStone Scores®, it is apparent that the startups and SMEs are characterized by strong differentiation of their assets (intellectual property, real assets, and management) and connectivity (supply chain knowledge and management background) in the industry. Green chemistry advancements have long been academically- and technologically-driven, rather than being incentivized by industry cost, efficiency needs, or policy responses.

Since the fossil fuel-driven development and use of raw materials in the consumer goods supply chain remains dominant, what has driven the green chemistry market?

There has been substantial activity in the development of renewable feedstocks for a wide range of chemical processes, both replacements for commonly used "merchant molecules" and new compounds with interesting and commercially valuable properties. Claimed advantages for renewable feedstocks over conventional derivations from petroleum include lower greenhouse gas emissions, reduced toxicity, and lower costs. Most renewable feedstocks are produced through biological processes – primarily fermentation of plant sugars into the desired compounds or their intermediates – or thermal and chemical processes applied to cellulosic materials such as wood, agricultural waste, or non-food plants like switchgrass. In Finland, startups have started to consider bio-based pulp waste feedstock for new raw materials.

The evolution of the green chemical market is being driven by a combination of technical, regulatory, consumer preference, and economic factors (Anastas and Warner, 1998).

Improved chemical screening technology and advances in the science of mechanistic toxicology have improved our understanding of the effects of manmade chemicals on humans, animals, and the environment. The rapid advances in biotechnology achieved over the last several decades have created powerful, new toolkits for the manipulation of organisms (bacteria, yeasts, and algae) such that they produce industrially useful compounds with great efficiency and minimal waste.

6 Targeting economic development towards strength in selected sectors of emerging industries

In economic development discussions, investment strategies and vision statements tend to be very aggregate. Stimulating the cleantech economy or the bioeconomy – for example - is a very generic strategic objective. The challenge with these high level articulations is that many economies are competing in this space, and therefore the value from a foreign direct investment (FDI) or trade perspective rapidly loses steam and meaning.

Foreign direct investments by multinational enterprises (MNEs) are one of the main drivers of globalization and of the creation of global value chains (GVCs). Both inward and outward FDI is important to many economies, and links production across countries. In Finland, many corporate enterprises are subsidiaries of, or investments from, global MNEs. Since MNEs account for a substantial part of international trade flows – both within the firm and with arms-length trading partners – a well-articulated national policy strategy is at the core of successful FDI marketing and incentivation.

In Finland, Finpro helps SMEs go international, using export credit vehicles, and by encouraging foreign direct investment in Finland with taxation and other benefits. Clear delineations of the internationalization strategy in building green economies – asking what sectors of those emerging industries does the country have strength – are necessary. They send a message of how Finland's competencies are different from those in Sweden, Germany, or the UK. Delineation of sectors of strength and innovation articulate the value of FDI in the Finnish economy to aspiring corporate and financial investors from Europe, the US and Asia.

The financial network mapping tool discussed in the previous chapter, coupled to the sourcing and assessment of companies detailed in this chapter, provides a systematic approach to understanding the strengths and weaknesses of resources in the economy. On its website, Invest in Finland indicates broad opportunities in the bioeconomy, cleantech, healthcare and wellbeing, ICT, manufacturing, mining, and retail. As exemplified for the smart grid and new mobility industries – both subdomains of cleantech – not all industry segments that make up these industry networks are equally well represented in Finland. And not all companies in each industry segment are equally investable.

Smart Grid encompassed value added services built on the existing infrastructure in the economy. Biomimicry takes the learning from bio-based processes and designs to rethink construction, energy, and finance. Given the strength of Finland in industrial design, the computational and software industries that encompass the catalysts in new economies, and the heavy manufacturing and healthcare anchor industries that power the economy, biomimicry may well represent the 'smart bioeconomy' opportunity for the country.

6.1 Takeaways for economic developers

Three distinct ecosystems, tens of industrial sectors, hundreds of companies, one summary; what have we learned about Cleantech and its future from the Finnish perspective? Table 3 consolidates the most central findings by ecosystem.

Our analyses have clearly shown that for business and economic development purposes the only feasible approach to Cleantech is to deal with it by the ecosystem. The three ecosystems analyzed in this study – Smart Grid, Smart Mobility and Green Chemistry – all feature different industrial structures, make vastly different value propositions, address different markets and involve a very different set of stakeholders. There is little value in cursorily lumping them together under a quasi-common concept such as Cleantech or the Bioeconomy. These concepts have no substance as they do not refer to specific industrial or economic activity. Hence, it is also very challenging to develop concrete instruments for economic or business development purposes that are to promote such activity. At worst, scarce resources are put to suboptimal use, as they are allocated over a vast spread of individual companies and projects that might be a fit with the overall theme of Cleantech but have no common denominator in the form of an industrial ecosystem and its underlying value chains. Our results on the Bioeconomy provide for an excellent showcase.

Table 3 Summary of findings and implications

Smart Grid	Smart Mobility	Bioeconomy / Green Chemistry
Economic structure • Well established • Energy, telcos & electrical equipment as anchors • IT, software & data as catalysts • Telcos well positioned	*Economic structure* • Established • Transportation, electrical equipment, internet retail & wireless telcos as anchors • Integrated telco, IT, software & data as catalysts • Car manufacturing shifting towards becoming a catalyst	*Economic structure* • Very weak • No circular structures • Green chemistry reflects conventional chemistry industry value chain structures • Incipient links between pulp & paper and chemistry
Value capture position • Low dependency and replicability drive fairly strong position • Low leverageability of assets the only weakness • No clear differences between size classes	*Value capture position* • Overall good position for value capture • Enterprises command much stronger position than SMEs due to higher connectivity as well as lower replicability and dependency • SMEs even weaker than their Smart Grid peers	*Value capture position* • SMEs suffer from poor market access due to immaturity of market and the resulting dependency on large enterprises • Enterprises command a stronger position due to existing ties to legacy value chain segments that will be relevant in emerging green chemistry value chains as well
Investment grade • Plenty of identified business opportunities • Enterprises hampered by low scalability and high capital intensity of conventional business models • SMEs are much more agile • Both size classes sacrifice upside potential to low leverageability of assets	*Investment grade* • Plenty of identified business opportunities • Enterprises waste great value capture position on unscalable, capital-intensive business models • Start-ups & SMEs outshine both enterprises and Smart Grid peers in all investability metric • Low leverageability compromises potential upside	*Investment grade* • Great majority of companies, large and small, do not fulfill the criteria of growth financing • Business models and strategies have been laid out for more organic growth through slow industry evolution • SMEs are expected to partner with enterprises to gain market access and leverage their limited assets akin to biotechnology
Implications for enterprises • Internalization of both Smart Grid capabilities AND more agile, digital business models via (i) internal pilots (slow), (ii) acquisitions, or (iii) partnerships (fast)	*Implications for enterprises* • Adoption of scalable business models via *learn-and-let-go* strategies • Acquisitions • Paradigm shift towards opening the business as a platform for smaller peers	*Implications for enterprises* • Weak signals of takeoff of opportunities to enter new markets for biomass producing industries • Emerging regulation against fossil energy-based industries a threat to incumbents in the sector
Implications for SMEs • Focus on building out market access networks • Partnering w/ enterprises a quick first option • In the long run, generic digital market platforms a better option to avoid dependencies on large companies	*Implications for SMEs* • Very weak value capture position mandates partnerships w/ well-positioned incumbents • Pursuit of niche & unbundling strategies a viable alternative	*Implications for SMEs* • Weak signals of business opportunities in the commodity chemicals industry as a refiner of biomass-based raw materials for the specialty chemicals and diversified chemicals industries
Implications for econ. developers • Promotion of partnership accelerators • De-risking of ecosystem-specific, full-scale pilots • Establishment of system of systems –level standards via regulation	*Implications for econ. developers* • Enhancement of interconnectivity between platforms and businesses built on them via establishment of system of systems -standards	*Implications for econ. developers* • Improvement of alignment of policies with true industrial momentum • Identification of bioeconomy growth sectors that can leverage strong assets in IT, software and data processing (biomimicry) • Regulatory interventions to break vested interests of industrial sectors with the petrochemicals industry

Economic developers need to better align development instruments with identified industrial momentum – based on an in-depth understanding of the businesses and industries involved in any given emergent ecosystem – to avoid overly long and costly strategies with little economic impact in the short- to medium term. Instead of pumping resources into policy-driven excitement, our results call for a focused approach, supporting existing – if incipient – industrial drive with ecosystem-specific instruments.

Our results show that even the more promising ecosystems such as Smart Mobility and Smart Grids are in the throes of growing pains. There is much that economic developers can do efficiently to alleviate them. The poor leverageability of industry assets and connections for market access across the board speak of fragile, budding industry structures that make it difficult for companies to establish robust markets and steady businesses in the short term. Companies of different sizes suffer the symptoms in their own ways. On the one hand, large incumbents do wield the assets necessary to conquer the ecosystem – telecommunications operators seem to have an especially favorable vantage point in smart ecosystems – but shoot themselves in the foot by applying conventional, capital-intensive business models that leave the door open for more agile growth companies that harness the potential of digitalization to exploit opportunities. On the other, start-ups and SMEs indeed show the drive and lean on nimble enough business models but utterly lack the assets for a full-scale conquest.

It is easy to envision a symbiotic relationship, in which incumbents provide the capital-intensive assets while their smaller peers introduce the competitive business models. Given the incipient structure of the ecosystems, however, just finding appropriate partners can incur considerable transaction costs. Here economic developers can step in, helping to find matches via collaborative accelerators that broker partnerships between industrial heavy-hitters on a mission of industrial renewal and small growth companies looking for resources and downstream assets.

Finding partners is a formidable challenge in and by itself, but our conclusions point to even more systemic impediments to industrial renewal that lie outside the industry's sphere of influence. One such is the lack of proper standards for the interconnectivity and interoperability of the various, often proprietary, IT systems that the numerous stakeholders to ecosystems run their businesses on. Especially smart ecosystems by definition build on the seamless interoperability across diverse system architectures and organizational boundaries. In the absence of universal standards, interconnectivity needs to be established one relationship at a time, building on contractually agreed, customized solutions that do not scale beyond the specific relationship. Economic developers can considerably speed up the construction of a digital business environment by introducing universal standards that promote the emergence of plug-and-play platforms for efficient interoperability (cf. Seppälä and Mattila, 2016).

Standards are needed for data security and personal safety as well. In a world of autonomous, self-driving vehicles and applications that affect offtake and feed into electricity grids, quality and safety controls for algorithms that govern these systems will be paramount for individual and societal safety. Thus, it has been proposed[30] that, in order to guarantee objectivity and to avoid moral hazard traps, agencies akin to those proven effective elsewhere – such as the

[30] The authors would like to thank Dr. Timo Seppälä and Juri Mattila for sharing fresh insights on the newest, yet unpublished discussions on the necessity of governing structures in the era of interoperable systems of systems.

Food and Drug Administration (DFA) governing foodstuff and medicinal substance approvals in the US – be instituted to govern the approval of algorithms that are introduced into networked systems such as those necessary to run Smart Grids and Smart Mobility environments. Early establishment of central bodies that set the boundaries of the playing field will help in promoting clarity and standardization in incipient ecosystems the growth of which suffer from a cacophony of competing and incompatible standards.

Finally, economic developers and governments can speed up the emergence of sustainable ecosystems, such as Green Chemistry, by driving the decoupling of industry sectors from petrochemicals and other environmentally harmful substances via legislation. The challenge is to introduce effective enough disincentives that are sufficiently strong to overcome the institutionalized vested interests that many industrial sectors share with those providing fossil-based raw materials. Incipient links to alternative raw material sources – such as biomass – can already be observed in relational data on industry links, but they are still very fragile and extremely dependent on fossil raw material prices. The current plunge in the price for oil is a great example of a strong deterrent to entry for sustainable alternatives.

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