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FIRM DECISIONS AND STRUCTURAL TRANSFORMATION IN THE CONTEXT OF INDUSTRY 4.0.

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Abstract

The first year of the Industrial Development Think Tank research tackled the record of structural transformation of the South African economy including the factors that underlie the observed outcomes. The research adopted a combination of analytical frameworks including political economy analyses, global value chains, capabilities and competition, rivalry and barriers to entry. The current research agenda builds on the work conducted in year one and sets out to examine questions relating to firm decisions and structural transformation in the era of industry 4.0. At the centre of this exercise is understanding how firms take decisions to invest in technological upgrading including the factors that facilitate or constrain the ability to do so. As such, it is important to study the technologies in context of their various applications. This requires the research to be embedded in sectors/industries. Therefore, the analysis requires a detailed understanding of various conceptual frameworks as understanding the introduction, use and diffusion of new technologies within these ecosystems is of critical interest, as well as how changes to these dynamics impact structural transformation in the South African context.

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1 Introduction

The first year of the Industrial Development Think Tank research tackled the record of structural transformation of the South African economy including the factors that underlie the observed outcomes. The research adopted a combination of analytical frameworks including political economy analyses, global value chains, capabilities and competition, rivalry and barriers to entry. The research identified a number of challenges for achieving structural transformation in the economy including weaknesses in building productive capabilities (Bell *et al*, 2018). However, despite these weaknesses islands of capabilities were identified in sectors such as machinery and equipment. The challenge then for the year 2 research is how to leverage the existing capabilities to take up emerging opportunities and tackle the challenges associated with industry 4.0 to facilitate structural transformation. This concept note concisely sets out a framework for understanding the role of technological change in achieving structural change in the context of the industry 4.0 and how this can be facilitated. At the centre of this exercise is understanding how firms take decisions to invest in technological upgrading including the factors that facilitate or constrain the ability to do so. This concept note complements other work being done in the broad area of industry 4.0.

The range of technologies that are associated with industry 4.0 have different implications for productivity gains in different industries. As such, it is important to study the technologies in context of their various applications. This requires the research to be embedded in sectors/industries.

Modern production systems are best described as 'complex multi-layered systems, spanning across different economic sectors' (Andreoni, 2017:2). Therefore, understanding their architecture and transformational dynamics, emergence, decline and renewal requires new approaches. Against this backdrop, it is necessary to understand the agglomeration economies that exist due to clustering by firms, as this provides a more intimate exploration of the linkages and interdependencies present among firms. This is especially important in industries which can be identified as 'root' industries (using the terminology adopted by South Korea) such as plastics and chemicals, and machinery, electrical machinery and electronics. These sectors are critical as intermediate industries. Understanding the introduction, use and diffusion of new technologies within these ecosystems is of critical interest, as well as how changes to these dynamics impact structural transformation in the South African context.

2 Technological change and structural transformation

The role of technological change as a driver of structural transformation is well established in economic literature (see for example Singh, 2004; Greenwood and Seshadri, 2005; Herrendorf, *et al*., 2013). The reallocation of resources that underlies structural change is aided, in part, by the use of technologies that can boost the levels of productivity in the economy and, in turn, economic growth. This process of technical change also requires upgrading of capabilities including organisational capabilities which entail the acquisition of tacit knowledge and creation of policies that assist in the accumulation of technology (Lall, 2000 and Khan, 2013) and the ability to innovate through developing new and improved products and processes (Fagerberg *et al*., 2010).

The processes of technological change require access to resources, such as information and communication systems, transport and skilled labour, and knowledge about how to access, keep and exploit the knowledge (Fagerberg and Srholec, 2017). Changes in technology can come from a variety of different channels such as through direct investments by firms and/or the state in new technology, the adoption of existing technologies through trade, through the upgrading of the skill and education levels in the economy, or from addressing and correcting market imperfections such as barriers to entry and the high levels of concentration.

Fully realising the gains from new technologies is dependent on existing technologies and skills which may or may not be available. Therefore, successful adoption and diffusion of any new technology is dependent on the cost of the technology, the availability of complementary technologies, as well as skills required to utilise these new technologies efficiently.

2.1 The role of industry 4.0 in driving structural transformation

The fourth industrial revolution entails a convergence of a range of developments in previously disjointed fields such as artificial intelligence and machine-learning, robotics, nanotechnology, 3-D printing, and genetics and biotechnology.[1] It's important to note that though some of the technologies that characterise 4IR are relatively old, there have been significant improvements over time with wider applications, and the business models linked to the 4IR bring them together in an unprecedent way. For example, 3D printing, which plays an important role in prototyping and production of components into manufacturing today, has been in existence since the early 1980s.[2] More recently the combination of 3D printing (also referred to as additive manufacturing) with advancements in material science and advanced design software has led to significant improvements to prototyping and increased productivity in manufacturing. The falling prices of 3D printers have also allowed for wider application in mainstream manufacturing.

The impetus of the fourth industrial revolution has been the Internet of Things (IoT), which allows firms to have real-time connectivity of different components/modules within a production system/ecosystem and is built upon four dimensions.[3] First, connectivity implying the integration of processes within an ecosystem (a concept elaborated on below) to form one system rather than separate systems interacting individually. Second, speed which relates to decreasing turnaround times for production and maintenance. Third, accessibility which involves giving every member of a firm access to all the tools and data they might require in order to do their jobs. Fourth, is anchoring which entails embedding production systems within the identities of firms so that the firms are able to continually improve the system and collaborate more effectively across and within departments. This has implications for productivity and the reduction of waste on production lines as well as ultimately reducing costs that will benefit the end user as a result.

Strategies to exploit the opportunities brought about by the fourth industrial revolution need to also consider changes to the organisation of production. These include, the uncertain nature of many of the new production and business techniques will require firms to rethink their

[1] Schwab (2016) describes 4IR as "a range of new technologies that are fusing the physical, digital and biological worlds, and impacting all disciplines, economies and industries". (See other articles on this such as https://www.weforum.org/reports/the-future-of-jobs)

[2] Similarly, the advent of computers and robotics, which also dates back to the 1980s, has revolutionised the way business is conducted and has greatly improved the productivity of workers in different ecosystems. See https://www.autodesk.com/redshift/history-of-3d-printing/ for a discussion on the history of 3D printing.

[3] https://www.mckinsey.com/business-functions/operations/our-insights/how-the-internet-of-things-will-reshape-future-production-systems

strategic focus necessitating a patient, longer-term view. The type of research and development needed, apart from requiring significant injections of capital, also requires the adoption of experimentation in using different technologies and production methods on the part of firms. Furthermore, firms will need to inwardly examine their cultures and strategies, adjusting them to become more accommodating to the technological changes of 4IR.

The fourth industrial revolution has the potential to create entirely new markets, and with them new jobs, that did not exist before. Therefore, the most significant challenge for firms and policymakers is understanding and developing the skills that are required by the new technologies as well as being adequately prepared to internalise, reskill and reallocate the workers who will inevitably lose their current employment.[4]

Traditionally, job losses from automation were associated with the dichotomy between tasks that are routine vs non-routine (Autor, et al., 2003) where more routine tasks typically faced a greater chance of becoming automated. Advancements in computer and AI technology, however, have allowed for less-routine tasks to be performed by robots (Susskind, 2017). This could lead to greater losses in employment in the future as the rate of technological advances increase over time. In contrast, the integration of advanced processing power and robotics into many industrial ecosystems has the ability to unlock significant productivity gains which can be leveraged to grow the economy and jobs in related industries and sectors. Thus, policymakers in developing economies, like South Africa need to take a proactive role in preparing these economies for the workplace of the future. Policy coherence and cohesiveness on the part of the state, its departments and institutions, as well as a commitment to growing the skill levels in the economy is a necessary precursor to success in the 4IR.

3 Understanding technological change in the context of 4IR

The fourth industrial revolution places emphasis on the interdependencies between firms and collaborations with institutions. As such, the studies need to understand technological change and the relationship with increased productivity in the context of ecosystems of production. In this section we consider conceptual frameworks that explain technology and learning in the context of ecosystems of production, namely (i) global value chains (GVCs), (ii) innovation systems, (iii) clustering and (iv) industrial ecosystems.

3.1 Co-evolution of global value chains and innovation systems

The technological change that has been associated with industry 4.0 is taking place in the context of globalisation. As such, there is a need to understand the characteristics of the technical change and the impact on the geographical location of production (Sturgeon, 2017). This requires an assessment of strategies of multinational corporations (MNCs) including those related to outsourcing, offshoring and reshoring. The global values chains analytical framework provide useful tools for this analysis.

Many plastic and machinery, equipment and electronic system products are intermediate goods which rely on linkages with input suppliers, final consumption industries and related services. Value chain frameworks highlight the importance of linkages and raise questions of governance by companies and distribution of power at different levels in the chain. Firms also share knowledge and practices vertically through the supply chain. There are strong collective

[4] https://iiot-world.com/connected-industry/nine-challenges-of-industry-4-0/

benefits (positive externalities) from developing a pool of skilled labour and facilities including testing and research facilities for design and product development. These all mean cumulative causation at work in patterns of growth and decline.

International linkages, through learning by exporting and FDI spill overs, play a role in providing access to technological knowledge and generating learning and innovation activities (Gereffi et al., 2005, Gereffi, 2014; Kaplinsky, 2000 and Humphrey and Schmitz, 2002). However, the gains from participating in a GVC are dependent on power asymmetries or the governance structures which determine where and by whom value is created and captured (Gereffi and Lee, 2012) and how this enhances or hinders capability upgrading. The literature identifies five basic types of value chain governance structures i.e. market, hierarchy, modular, relational and captive relationships (Gereffi and Fernandez-Stark, 2011). Although the concept of governance is widely captured in GVC literature and has evolved over time, the exertion of power is now seen as not being limited to a 'lead' or powerful firm but can be shaped by various factors and actors in a value chain (see for example Dallas et al., 2017). Understanding the role of lead firms in driving technological change (or not) is especially relevant to the South African context given the poor upgrading evident in industries that are participating in GVCs.

This problem is not unique to South Africa, as there are questions around the circumstances under which insertion into GVCs creates opportunities for developing countries to deepen their technological and innovation capabilities and more specifically the mechanisms and institutional support required for firm upgrading (Morrison et al., 2008 and Lema et al., 2018). Indeed, participating in GVC does not necessarily lead to technological upgrading. A more integrated approach to understanding the process of building capabilities through GVC participation requires integrating the GVC framework with learning and technological capability development (Lema et al., 2018). This allows for an assessment of the opportunity, speed and intensity of upgrading through the study of innovation theories or systems.

The innovation systems approach is grounded on the idea that national systems of innovation are *open* systems contribute to developing capabilities and local competitiveness.[5] This is based on the premise that learning and innovation processes do not simply unfold within individual organisations. They are often interactive and occur in organised systems and broader societal arrangements which unlock knowledge creation. This brings together local, national and global learning. The co-evolution of the GVC and innovation systems frameworks provide a chain of relationships where local firms remain at the centre of the innovation process (Lema et al., 2018). It illustrates that critical mechanisms enabling learning and innovation in GVCs can emerge from firms making deliberate efforts to build internal capabilities. Moreover, learning opportunities are most effective when complemented with local knowledge channels such as through clusters (discussed further below) and national innovation systems, in collaboration with other bodies such as local universities (Lema et al., 2018).

The rise of reshoring[6] in industrialised economies, is also changing the structure and organisation of GVCs as we have traditionally come to know them (Barzotto, Corò, De Propris

[5] A system of innovation refers to a grouping of (market and non-market) actor networks that foster the creation, transfer, adoption, adaption and diffusion of knowledge through learning processes (Lema et al., 2018)

[6] Reshoring is the moving of manufacturing back to the country of its parent company (Ellram, 2013)

and Volpe, 2015). Where previously firms were off-shoring low value-added operations to low cost labour locations and performing high value-added activities, technology developments have allowed firms to reshuffle their production locations and strategies.[7] South Africa therefore needs to understand the implications of the relocation of production activities and services on manufacturing competencies, skills and innovation capabilities and the development of industrial ecosystems (Barzotto et al., 2015).

The usefulness of the GVC lens of analysis in understanding how to leverage developments in technology therefore lies in its complementarities with local innovation systems that serve to strengthen GVC participation. Moreover, the analysis should consider the strategic role of lead firms as key actors of value chains, as emphasised in GVC scholarship, is order to understand how they influence the capacities of participants to upgrade their activities. This all needs to be understood within the context of how modern GVCs are organised and structured.

3.2 Clustering and innovation

In the same way that aspects of the GVC analysis above are merged with the innovation systems approach for a better understanding of technological upgrading, literature around clustering has recently been shaped in the context of innovation systems that emphasise the importance of access to knowledge, skills, demand, finance and institutions (Fagerberg, 2016). While the GVC approach brings out elements of learning from geographically dispersed and fragmented production networks (Gereffi et al., 2005, Gereffi, 2014), the clustering framework emphasises the importance of localisation and the creation of dynamic linkages for achieving increased competitiveness, as well as the upgrading of firms (Porter, 2000). The literature also emphasises the importance of collaboration among different stakeholders in the cluster, given the interdependencies present (Götz & Jankowska, 2017). For example, the competitiveness of component manufacturers has a direct impact on the downstream lead firm, at the same time the standards specifications and requirements of the lead firms may propel innovation among the component manufacturers upstream.

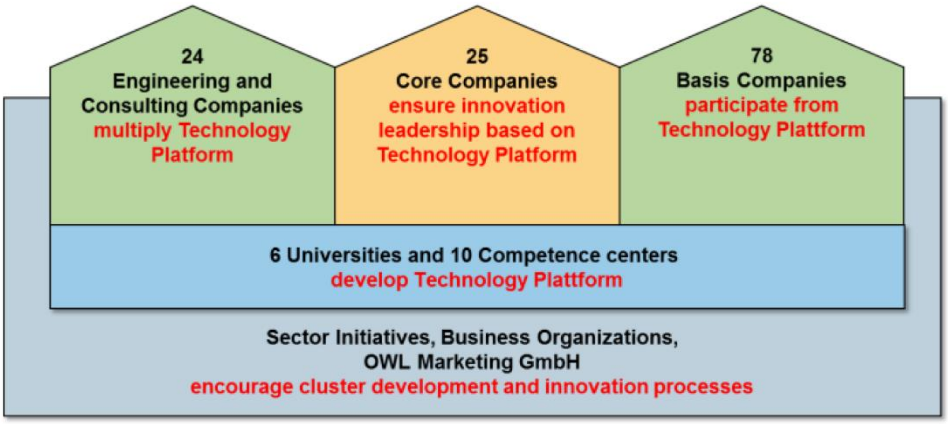
Clusters are viewed as 'repositories of competencies' and provide adequate mechanisms that facilitate effective diffusion, accumulation and absorption of knowledge (Götz & Jankowska, 2017). The fundamental aspect of the fourth industrial revolution is access to knowledge, and companies view knowledge as a source of competitiveness and a prerequisite for successful participation in international trade and investment (Fagerberg & Srholec, 2017). Furthermore, firms require favourable environments to share this knowledge, such that clusters or regional hubs of expertise provide this basis, especially for small and medium enterprises. This policy tool is extensively applied in developed countries including Germany, the UK and Australia, and have come to include core institutions such as firms, engineering and consulting companies, tertiary institutions and industry associations (see example in Box 1).

Box 1: It's OWL cluster in Germany

It's OWL – Intelligent Technical Systems OstWestfalenLippe cluster agglomerates 173 companies, universities and research institutes as well as other organisations that work collectively on achieving

[7] The footwear industry (Adidas) is an example of where reshoring has occurred, largely due to the ease of additive manufacturing (through 3D printing) which is disrupting traditional supply chains and locational advantages of low cost developing countries.

the innovative leap from mechatronics to intelligent technical systems (see figure below). The cluster is located in Paderborn, West Germany and offers services on technology transfer, learning networks and marketing, training, Industry 4.0 checks and consultation.



Within this framework products and production innovations are developed by business and science in close collaboration. The spectrum ranges from intelligent sensors, drivetrains and automation solutions through machines, household appliances and vehicles to networked productions plants. The new technologies are made available to a large number of small and medium-sized enterprises via transfer projects.

Source: www.its-owl.de

The selected sectors require high investment outlay given the rapid technological advancements, such that creating a space that can be used to share resources (such as testing centres) and foster innovation through simultaneously competing and cooperating (coopetition), can lead to synergies. As a result, companies (especially small and medium enterprises) in clusters can be better placed to enter the export market and contribute towards diversifying a country's industrial structure.

However, economic agents in a cluster may become reliant on regional capabilities and become locked in on a particular trajectory. This can result in a situation where firms develop more technologies that are related to the cluster, missing out on new advances (Fagerberg, 2016). To avoid this Neffke, Matté, Ron, & Henning (2018) propose that local economies need to continuously develop new unrelated capabilities in order to remain competitive. This obviously occurs through reallocating resources and tapping into the spill over effects from being part of global value chains as postulated by (Lema, et al., 2018), in the discussion above. The potential for the cluster to create more technologies will also be reliant on the quality and strength of local innovation systems. In other words, the development of clusters does not solely depend on internal linkages, but also depend on capturing the global evolution of knowledge, for the purpose of driving innovation and the development of dynamic capabilities (Lema, et al., 2018).

Since knowledge and adopting fourth industrial revolution technologies is a risky and uncertain process, the process requires conditions that are intrinsic to a cluster – mutual trust, compatibility, close cooperation and shared norms. Moreover, a cluster setting allows firm to share background and understanding of commercial and technical challenges that are inherent to their location. These conditions are especially important because industry 4.0 embodies the concept of 'connected enterprises' and requires close cooperation with different stakeholders in the cluster. The more tacit the knowledge is, the more important is physical closeness and direct contact (Götz & Jankowska, 2017).

While the IoT means that firms are able to share real time information and transcend beyond being present in the same location, the gains from being located in the same geographic location are still relevant. From an agglomeration economies perspective, the geographic concentration of firms can act as a pool of knowledge, creating a base of expertise in ICT, robotics, and other technologies crucial to industry 4.0 (De Marchi, et al., 2017). The development of internal firm capabilities can be enhanced through advantages of geographical proximity, which can be extended to city, regional and national borders.

The Durban Chemicals Cluster in South Africa embodies the importance of physical proximity in developing local capabilities. The cluster is comprised of 46 members that include chemical manufacturers in different industries (petro-chemicals and gas; water treatment; coatings, inks, adhesives and dyes; resins and polymers; pulp and paper). Since its establishment in 2009, there is anecdotal evidence that firms in the cluster have improved competitiveness through cluster programmes aimed at boosting investment and growth, operational excellence and skills development, along with industry transformation. For example, the cluster has a training programme targeted at recent graduates in chemical related fields and provides graduates with a holistic business understanding with theoretical and practical training on: (1) induction, (2) quality, (3) manufacturing, (4) commercial and (5) health and safety. Through this programme, the cluster ensures that the industry has access to highly skilled chemical engineers.[8]

Overall, the development of effective clusters and innovation systems is still nascent. While, clustering is a policy tool that has its roots in the early 1990s, only a few cluster initiatives have taken off. In 1994, the Fund for Research into Industrial Development, Growth and Equity (FRIDGE) process proposed the development of downstream steel sector clusters in the automotive, wire and rod, tubes and pipes, and carbon steel industries. The effects of the East Asian and Russian Crisis in 1998 and the lack of corporate leadership contributed to the failure of these clusters (Rustomjee et al., 2018).

The turn of the 21st century reignited the interest in clustering strategies following the decline in competitiveness among local firms, and the lack of government support to address firms' challenges (Bell et al., 2018). While clusters exist in the Western Cape (Cape Clothing and Textile Cluster) and KwaZulu-Natal (Durban Automotive Cluster and Durban Chemicals Cluster), there still is room for further sustained effort on the part of the state to leverage off these initiatives. These can be developed in ecosystems which have strong linkages to other ecosystems, especially considering the productivity and efficiency gains to be had in the fourth industrial revolution.

Thus, the analysis at hand should compare the experience of clusters in the selected industries to those in countries that have been particularly successful in using clusters to facilitate technological change.

[8] See https://durbanchemicalscluster.org.za/

3.3 Industrial ecosystems as drivers of technical change

The industrial ecosystem approach is grounded on complex system theories and integrates ecosystems with capability theories, structural learning and economic geography (Andreoni, 2018). The complex systems literature highlights that firms should not be viewed in isolation, but rather as part of an ecosystem, where they cooperate, compete and co-evolve to create a system of complementary capabilities around new innovations (Moore, 1993). Though this is not a new concept, its application has increased and evolved in the context of industry 4.0.

The industrial ecosystems approach shares the same underlying principles and draws on the innovation systems literature, which identifies interactions amongst firms and institutions as drivers of industrial innovation and competitiveness (Andreoni, 2018). Industrial ecosystems essentially link a firm's value creation process with a broader complex system of interdependent activities involving multiple heterogeneous actors (i.e. organisations, institutions, governments, academia and markets). However, the framework puts forward alternatives to some of the fundamental challenges inherent in innovation systems, to provide a more dynamic, systemic and value creation representation of industrial innovation.

Industrial ecosystems go beyond simply recognising the role of institutions in shaping innovation and industrial dynamics, to understanding the structural configuration of production systems. This includes bargaining power, competition and cooperative strategies. The approach especially links production and innovation to the political economy of industrial ecosystems, acknowledging that the distribution of power among organisations and networks is often unequal (and industrial policies have to govern interdependent, but conflicting interests) (Andreoni, 2018). These governance structures, which are widely reflected in global value chain literature, determine who the players are, who captures the value, and the extent to which value is retained or redistributed in an ecosystem.

The analysis of an ecosystem is not bound by national or regional systems, which tends to ignore production and technological linkages across regions and nations. The framework instead proposes that geographical boundaries be defined by the value creation process and the structure and evolution of interdependencies. Real boundaries can therefore only be identified by tracking the network of value creation linkages involving organisations around and beyond a regional core. Identifying the real boundaries can assist policy makers in supporting and transforming industrial ecosystems.

Industrial ecosystems further emphasise understanding industrial production alongside innovation. The approach is therefore centralised on the production-innovation nexus which requires an understanding of technology platforms (i.e. different types of production technologies). This is important for analysing technological change.

The industrial ecosystems approach is thus structured around *capability domains* (technology platforms) and *sectoral value chains*. Andreoni (2018) identifies capability domains as distinctive clusters of resources and capabilities developed by heterogeneous organisations and institutions (including firms, intermediaries and demand-side actors). The production or technological base of a firm is the pool of resources and capabilities (machines, processes, skills and raw material) related to the production process which a firm extracts to create value products and capture opportunities. The movement into a new technological base requires that a firm develops competences in some significantly different area of technology. Capability domains therefore include different types of technologies – generic, proprietary, infratechnologies (measurement, testing and prototyping tools critical in leveraging generic technologies) and production technologies, which may find application in multiple sectoral value chains i.e. pervasive or transversal.

Given the blurring of sectoral boundaries, using a sectoral analysis for studying value creation and capturing industrial dynamics is often problematic. In an ecosystem, firms may operate within one or more defined sectors along different segments of a value chain. It is therefore more effective to understand firm dynamics in terms of functional processes which cut across industrial lines. The ecosystem approach adopts a *value chain open system unit of analysis*, treated as systems that are not defined by traditional sectoral boundaries. An ecosystem is distinguished by different organisations who in one way or another are involved in a co-value creation process. These include (i) focal firms (system integrators), (ii) suppliers and complementors (including specialist contractors) and (iii) institutions (Andreoni, 2018).

The value creation in an ecosystem occurs through the interdependencies linking the system integrators with their suppliers and complementary downstream linkages. This connectedness and links to other technology platforms, implies that in order to manufacture competitive products, there is need to develop complementary capabilities cutting across different stages of the value chain. For example, for a company to develop engineering and design capabilities, it needs to be involved in the design, research and development and prototyping. Thus, specialisation requires an intimate understanding of the various capabilities that constitute the underpinning of the technology platform (Andreoni, 2017).

The industrial ecosystem is illustrated as a matrix or '*production space'* where heterogeneous organisations operating in one or more sectoral value chains draw on one or more capability domains to perform a number of production and technology functions in processes of co-value creation, diversification and innovative industrial renewal. The production space is a space of opportunities and constraints. While there are potential productive capabilities that can be exploited, the production space can lead to transformation failures or the decline of an ecosystem altogether.

The evolution and ability of an industrial ecosystem to assimilate cross-technology innovation, and benefit from them depends on the technology readiness levels (TRLs). TRLs are used as metrics to assess the extent to which technologies (machine, equipment or software) are ready to be deployed in production processes (Andreoni, 2018). This requires coordination and organisation of production capabilities across different drivers, supportive technological infrastructure, and financial infrastructure, in the public and private sphere. The ability of an industrial ecosystem to create and capture value also requires firms to have the necessary capabilities to understand, absorb and exploit knowledge (Fagerberg and Srholec, 2017). Lack of coordinated effort towards ensuring technological readiness in the closely complementary technologies might lead to the inability to create and capture value (Andeoni, 2017).

Developing economies in particular, need to strengthen capabilities and develop ecosystems that allow knowledge flows and interactive learning (Lema, et al., 2018). As such, change within an ecosystem should be understood in terms of co-evolution among systems, rather than as the adaptation of individual systems to their environment (Kay, Leih, & Teece, 2018).

4 Implications for evaluating technology and learning in South Africa

The different frameworks considered in section three propose ways of understanding the organisation of production and technological change in the context of interdependencies. The frameworks will be employed in the studies being undertaken in the programme of work in the second year of the IDTT will explore technological upgrading through different ecosystems as well as draw out implications for policy makers. They will also inform the cross-cutting inputs which will be made on developing a digital industrial policy framework.

The conceptual frameworks place emphasis on building internal firm capabilities, elements of cooperation, shared dependencies and networks – both between firms and with support institutions. The research being undertaken is involved a firm-level analysis and a consideration of other supporting structures and organisations linked to technological change. As such, the research will consider the following in analysing technological change using the industrial ecosystem framework:

i. Identifying the technology areas of a lead firm in the ecosystem in order to map out distinct resources or capabilities that have been developed

ii. Understanding production and technology bases and their application across sectoral value chains

iii. Defining the boundaries of the ecosystem based on value creation linkages

iv. Understanding diversification dynamics by considering similarities and complementarities in technologies embedded in the ecosystem

v. Establishing the organisational structure and dominant governance mode characterising the ecosystem

vi. Determining the technological or structural readiness levels of the ecosystem

vii. Understanding the demand side actors and markets since quality and quantity changes open and shape the productive opportunities of firms.

The general categories of information required for this analysis therefore include a list of products and services provided by a firm, the distinctive clusters of technologies and their cross sectoral applications, as well as identifying the network of value creation linkages (i.e. supply and demand side actors) in the ecosystem.

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