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Studying innovation ecosystems using ecology theory

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ABSTRACT

This paper proposes a set of perspectives for studying innovation ecosystems that are based on ecological research. Our perspectives are based on fundamental similarities between natural and business systems. We suggest that innovation ecosystems can be defined as pathways of interlinked business models. Pathways are characterised by the flows they convey not the types of business model that support the flows. These pathways convey material and informational resources, as well as value. Like the nutrient and energy pathways in natural ecosystems. Pathways help to recycle scarce resources such as customer attention and customer-derived information. Business model descriptions are similar to an organism's genome in that they describe limitations on sensing, acting and understanding. We conceptualise this as the 'umwelt'; the self-world. These limitations have implications for how firms and customers interact with customers. They have other implications for how firms interact with each other in business model communities and how they accommodate each other.
We illustrate and test these ecological perspectives using a case study of a healthcare smartphone app's ecosystem. We find that our perspectives can be used as novel methods of studying interactions between business models; or to study ecosystem building.

1. Introduction

The 'Internet of Things' (IoT) is based on sensors and a Wi-Fi connection to the cloud that are cheap enough for almost any product to be connected to the Internet. It can then share data with other Things (Porter and Heppelmann, 2014; Porter and Heppelmann, 2015). Even wooden pallets have been able to share location data when Radio Frequency ID chips are stuck to them. This is what originally enabled UPS to give their customers a service that told them where their packages were and how long until it was delivered (UPS, 2005). Modern mobile phones combine location, movement and other sensors with powerful information processing capabilities and several different types of wireless connectivity.

Terms like 'digital ecosystem' are commonly used to acknowledge the interconnected nature of new digital industries. One example of this is the idea of a 'smart city' which combines elements of the Internet of Things but with a focus on particular urban spaces and the people and organisations that live and work in them (Chourabi et al., 2012). However, it is far from clear how to construct a smart city or how to make a city smart because it has never been done before. Smart cities themselves are emergent phenomena; like the Big Data and IoT technologies that enable smart cities. Emergents that have not been seen before are impossible to predict. The component hardware, software and mathematical tools of Big Data are being invented, combined and recombined in different ways and it is by no means obvious how this will turn out. The same complex forecasting problems also apply to IoT products. But new products and services can be deployed differently with different business models (Chesbrough, 2010). New start-ups are experimenting with new business models every day. Old firms are experimenting with new ways to use their data in new data products. Governments are trying to understand how to use this innovation to encourage prosperity whilst safeguarding their citizens' interests.

It is confusing for business people, governments at all levels and consumers of these new products and services. It is crucial for us to improve our understanding of what is happening and our prediction of the way that things will go with product design, consumer tastes, regulatory decisions (e.g. especially data sharing) and partnerships between firms. Research is required to help all stakeholders make choices about these complex and quickly emerging innovation ecosystems. But the concepts that underlie terms like 'innovation ecosystem' or 'digital ecosystem' are neither well defined, coherent nor commonly accepted.

The term ecosystem originated in the science of ecology Tansley (1935). He used ecosystem to clear up a muddle in the terminology of plant communities. The issue was that plants are not only affected by their environment, but in return they influence the soil, atmospherics and animals. By folding the physical environment in with the vegetation the first principles were changed. Plant communities were identified by plant species, the presence and abundance of which was explained by

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concepts like evolution, competition, predation and mutualism. Species filled niches, which are defined by a role in the community associated with resource availability. With the environment folded in, those principles fail to be explanatory. In the ecosystem concept, flows of material and energy come to the fore. Connection and flux are the hallmark of ecosystems. In ecosystems animals melt away into pathways and become a connection between food eaten and waste expelled. Animals become connectors between vegetation and the soil. If a species disappears, another is available to play its role, so animals as items may still be present in an ecosystem, but as units they do not offer explanations of ecosystem function. The functional parts of an ecosystem are things like the nitrogen recycle. Grazers might deplete vegetation changing the albedo of the ground. That changes the local climate which affects the growth of plants.

The emphasis on connections and cycling makes the ecosystem a good analogy of what happens in systems of businesses. Business systems are not so much a matter of discrete players, embodied in human business workers. Instead they amount to complicated connections that carry the flux of money, information and other resources. The business ecosystem concept becomes a more apt notion when firms depend on the Internet. Ecosystems fluxes are not always apparent to the human observer. A river flowing is tangible enough, but a nutrient cycle is not. Many connections in business are important but not tangible.

In this paper we investigate innovation in a heath app data ecosystem by focusing on Quealth. Quealth is a smartphone app that is provided by the roadtohealth group, which is in turn partnered with Samsung and other firms. These firms make use of customer-related data to produce their services (roadtohealth, 2015c). We develop a theory of innovation ecosystems using ideas from ecology and the study of complex systems. We seek to use the some of the same methods that have been used in ecology. We suggest a way of developing and unifying a theory of innovation ecosystems.

2. Lessons from the study of natural ecosystems and complex systems

In ecological research complexity has manifested itself in a collection of specialisations such as population biologists who study ecosystem energy flux expressed as number of organisms. Landscape ecologists study spatial pattern expressed as process function. Whereas ecosystem ecologists study energy flux, biome ecologists study the many parts as units in a sort of object based versions of ecology. But some ecologists, biologists and systems researchers have called for a more unified view of ecological research that uses ideas from complex systems to be more explicit about the process of observation and data capture in ecology (Allen and Hoekstra, 2015). When ecological phenomena are investigated using methods derived from complexity theory we find many similarities to innovation ecosystems. This similitude is not just in some superficial level that is common to all systems but in the underlying functioning and organisation of their structures and processes. Here we seek to investigate whether concepts from this complex systems method of analysing natural ecosystems can be used to study innovation ecosystems. First we set out the logic for using methods from natural ecosystems to study human innovation ecosystems. Next we theorise how to conceptualise this in the context of innovation ecosystems of human products, services that are produced by commercial and government organisations. Finally, we use our new conceptualisation of innovation ecosystems to analyse one such innovation ecosystem.

2.1. Are concepts from natural ecosystems appropriate to use?

There are a number of arguments which support our proposal that some concepts from the ecological sciences can be used to benefit research into innovation ecosystems. We do not advocate a wholesale translation of well-known terms from ecology; instead we pick some specific concepts and explain their relevance and justification, separately and together in a coherent theoretical system.

Firstly, it has been noticed for some time that natural systems and business systems have marked similarities (Moore, 1993; Moore, 1996; Iansiti and Levien, 2004a; Iansiti and Levien, 2004b; Iansiti and Richards, 2006; Allen et al., 2013). Recently the innovation and entrepreneurship literature has started to use ideas that are associated with the term 'ecosystem' (Zahra and Nambisan, 2012; Clarysse et al., 2014; Nambisan and Baron, 2013). This research uses relatively simple biological concepts to generate valuable insights. But the biological and ecosystems research literatures each hold a vast array of rich ideas that are still to be used. Natural ecosystems and innovation ecosystems are both systems that are made up of entities joined by relationships and some of these relationships are organised in similar ways. The entities in both types of systems are heterogeneous and appear to behave at different spatial scales and at different natural frequencies. In both types of ecosystems entities compete, attack, consume and also help each other in mutualistic situations. Here we investigate these different commercial relationships in a deeper conception than has been done before by using ecological theory of how all those processes work. Natural organisms and species compete, attack, consume each other. But also they mutually benefit each other. Another similarity between the two types of systems is in the processes that drive behaviour and change. Natural ecosystems use solar energy to power their use of nutrients to live, grow and reproduce. Innovation ecosystems also use physical energy sources to power processes that use other resources and they also use value creation in a similar way to energy, as a way to motivate and influence processes that involve their human elements. And both types of systems use information as a resource for streamlining their behaviours at different system levels.

Secondly, the interconnectedness of both types of systems with positive and negative feedback loops on different scales and with different lags makes each system difficult to study. The vast diversity of natural phenomena that can be measured by different sensors and methodologies have long made ecology a science of specialisations. A different set of students have also specialised in business and in business research so as to cope with overwhelming amounts of information. In this way that haver scaled their research. Now society is using technologies like Cloud Computing and social media to create phenomena on a much larger scale. Much smaller scale phenomena that have until recently been beyond normal human senses are becoming indirectly observable using new technologies for sensing and analysing data. Big Data and Internet of Things have unleashed tsunami of phenomena that cannot normally be accessed by naked human senses. Methods of data gathering in ecology, like the quadrat, have long presented similar opportunities for quantifying research. Both ecology and business studies share errors such as collecting data for the sake of it, reifying particular phenomena because they are tangible while ignoring other phenomena because of bias.

Thirdly, both types of systems adapt to internal and external disruption. Natural and innovation ecosystems change continuously and change happens at different scales requiring different levels of analysis. Indeed, our focus here is very much on better understanding how commercial systems adapt and innovate at the level of whole ecosystem as well as on the levels below. Natural ecosystems adapt to new entrants, environmental change and the evolution of new capabilities that are enabled by mutations. We think that the underlying processes of adaption, not always through natural selection, have some similarities that can provide useful insights. They can be mapped from one type of system to another. Note how drivers of adaption could be used in the context of both types of system. We do not say that both systems are joined at some level; just that they are similar on more levels of organisation than surface mappings. We suggest that this similarity continues below the level of the obvious surface so as to allow us to learn from one type of system and apply it to another. Experimentation always requires an analogy between the system of interest and the model system.