PEGIS

Papers in Economic Geography and Innovation Studies

2019/02

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Arne Isaksen, Michaela Trippl, Nina Kyllingstad, Jan Ole Rypestøl

University of Vienna | Vienna University of Economics and Business | Austrian Academy of Sciences | University of Agder | Kiel University

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January 2019

Arne Isaksen, Michaela Trippl, Nina Kyllingstad and Jan Ole Rypestøl

Arne Isaksen, Department of Working Life and Innovation, University of Agder, Jon Lilletunsvei 9, 4898 Grimstad, Norway; email: arne.isaksen@uia.no

Michaela Trippl, University of Vienna, Department of Geography and Regional Research, Universitaetsstrasse 7, A-1010 Vienna, Austria and Department of Working Life and Innovation, University of Agder, Jon Lilletunsvei 9, 4898 Grimstad, Norway; email: michaela.trippl@univie.ac.at

Nina Kyllingstad, NORCE Norwegian research centre, Universitetsveien 19, Kristiansand, 4630, Norway; email: niky@norceresearch.no

Jan Ole Rypestøl, NORCE Norwegian research centre, Universitetsveien 19, Kristiansand, 4630, Norway; email: jary@norceresearch.no

Abstract
The paper develops a conceptual framework for analysing wide-ranging 'digital transformation processes' of regional industries. We regard digital transformation as consisting of three main activities; development of scientific principles, making of digital products and services, and application of these in production and work processes. The paper advocates a comprehensive framework that challenges established economic geography approaches, which propagate firm-based views and centre stage skill and technological relatedness, in interpreting how digital transformation occurs. We discuss the role of institutional environments, focus on other actors besides firms and take a broader view on assets beyond firm capabilities, skills and technological knowledge. The paper thus provides an alternative conceptual framework for understanding digital transformation processes in regional industries, which we illustrate with one example from each of the main 'digital activities'.

Key words: digitalisation, regional innovation system dynamics, new path development, asset modification

JEL codes: O33, R11

This is a pre-print version of a paper that has been submitted for publication to a journal.

INTRODUCTION

Economy and society are facing substantial transformation pressures. One important challenge (and opportunity) is digitalisation. Digitalisation is described as 'a broad swath of digital tools and infrastructure (e.g., 3D printing, data analytics, mobile computing, etc.)' (Mambisan, et al. 2017, p. 224) that can result in a wide range of innovation outputs for several application contexts. Digitalisation may lead to great changes in organisation and innovation in industry and in regional and national economies, and we may need other conceptual tools than those used for analysing 'ordinary innovation activity' to study such changes (op. cit.).

This paper examines how digitalisation affects (different types of) regional industries. Explaining transformation processes of industries and regional economies is a key concern of evolutionary economic geography (EEG). The EEG approach explicates how new regional industries branch out from existing ones through the recombination of technological competence and skills in related industrial sectors (Boschma and Frenken 2011). Recent contributions have gone beyond standard EEG models, offering new research perspectives on regional economic restructuring. Some scholars have recently begun to employ a more systemic approach that considers other actors and agency besides firms (Tanner, 2014; Dawley et al., 2015; Steen and Hansen, 2018), networks and institutions (Isaksen and Trippl, 2016; Isaksen et al. 2018a). Others have argued for a multi-scalar perspective to overcome the dominant view on endogenous, that is, local processes (Binz et al., 2016; Boschma, 2017; Boschma et al., 2017; Trippl et al., 2018). Economic geographers have also advocated a broad understanding of assets, thus challenging the narrow focus of EEG on technological knowledge and skills (Cavalho and Vale 2018, Mackinnon et al. 2018a, b). Further, there is also an increasing awareness that branching (that is, related diversification) represents only one form of path development. Several authors call for paying greater attention to other potential types, ranging from path renewal, importation and creation (Isaksen et al. 2018a).

There is a need to better connect these recent advances into a coherent theoretical framework, which this article aims to contribute to. We propose a novel approach that takes heed of various forms of path development and links them to changes of innovation systems, which are conceptualised as modification of broadly defined assets (see Trippl et al., 2019 for a discussion and application of such a systemic integrative approach to green restructuring processes of regional economies). We apply this approach to 'digital transformation' processes of regional economies. Different types of 'digital activities' underpinning various types of path development are thus an integral part of the framework advocated here.

As 'clear definitions are the starting point for all research' (Baines et al. 2009, p, 554), the next section provides first a discussion and clarification of what we understand by digitalisation in terms of the knowledge and activities that underpin development and use of digital technology. Furthermore, we claim that industrial transformation such as digitalisation includes changes in both individual organisations and their surrounding context, here conceptualised through the notion of (regional) innovation systems. Digitalisation requires assets and modification of assets, such as new competence and institutional changes. We argue that different modes of modification, including re-use of existing assets, creation of new assets and destruction of old assets, are at the centre of transformative activities, leading to various types of regional industrial path development. The framework is in the third section illustrated by empirical investigations of three cases that represent three types of digital activities outlined in the theory section. The fourth section concludes.

CONCEPTUAL FRAMEWORK FOR THE ANALYSIS OF DIGITAL TRANSFORMATION

This section introduces and discusses the key elements of our conceptual approach and combines them into a systemic integrative framework for analysing digital transformation of regional industries.

1. Knowledge and activities framing digitalisation

Digitalisation involves, in short, employing digital enabling technology to innovate (Digital 21). Digital technologies are generic across many industrial sectors and public services, and digitalisation is the core of what is called a new industrial revolution, that is, industry 4.0 (Howaldt et al. 2017). In order to clarify and operationalise digitalisation, we define digital technology here by its key knowledge and activities.

Digital technology, like technology in general, should be seen as 'knowledge about physical processes ("hardware")' and 'knowledge about, say, how to organize/manage these ("software")' (Fagerberg et al. 2010, p. 839). When we stick to this broad definition and build on Smith's (2000) concept of distributed knowledge base of industries, we can distinguish three types of knowledge and activities that constitute the basis for developing, employing and diffusing digital technology. These are i) scientific knowledge that forms the basis for developing specific technologies; ii) knowledge, both scientific and experience based, that is necessary to produce particular digital products and services; and iii) knowledge (mostly experience based) of how to utilise digital products and services in existing and new production and service activities.

The first type of knowledge is codified, scientific knowledge that can be transferred quite easily in geographical space, and which is often based on publicly funded basic research. This knowledge is the building block for the development of digital technology. Mazzucato (2013, p. 95) demonstrates that 'there are 12 major technologies integrated within the iPod, iPhone and iPad', all of them have been State-funded. 'Apple concentrates its ingenuity not on *developing* new technologies and components, but on *integrating* them into an innovative architecture' (op. cit., p. 93). One such basic scientific field is 'algorithm that led to Google's success' (op. cit., p. 20).

The Apple example points to a second knowledge type and activity, that is, how to apply scientific principles to develop products and services that include digital technology, for example, robots and drones, and the knowledge to produce these products and services. While the first type of knowledge is about scientific principles, the second type of knowledge includes how to develop new and significantly upgrade existing products or services, and 'know how to embed these in a well-organized production and distribution system' (Fagerberg et al. 2010, p. 839).

The third type of knowledge involves knowing how to utilise digital technology, such as robots for dialogue, 'chatbots', for specific activities in the industry or public sector (Digital 21). Diffusion may take place through knowledge that is embodied in machinery and equipment (Smith 2000). For example, chatbots are used for customer contact in the banking sector, which requires knowledge about this technology and about how chatbots can be integrated into existing work processes.

The division of knowledge and activities that underpin digitalisation corresponds to some extent with how technological revolutions and new techno-economic paradigms are conceptualised. Firstly, technological revolutions include a set of interrelated radical breakthroughs that consist of basic scientific and engineering principles 'acting as the *big-bang* that opens a new universe of opportunity for profitable innovation' (Perez 2010, p. 189, italic in original quote). Secondly, technological revolutions give rise to new industries. Perez (2010, p. 191) distinguishes between motive branches that produce cheap inputs with widespread applicability and carrier branches that use the inputs to make new products. Examples are semiconductors as input and computers as product. Thirdly, there are induced branches, that is, industries that may have existed before, but are being modernised by using new technology. The techno-economic paradigm includes a commonly agreed best practice model of how to use new technologies across industries (op. cit.), that is, the technological revolution has widespread repercussions. Thus, we see here a similar distinction between basic scientific principles, the production of new 'hardware' technology, and the use of this in many parts of the economy. The rest of the conceptual discussion is largely organised around this distinction.

2. *Transformation of industry and the 'wider setting'*

Smith's (2000) work on distributed knowledge bases pays due attention to the institutional framework; 'the organisational forms - in terms of companies, research institutes, universities and so on - through which these knowledges are produced and disseminated' (Smith 2000, p. 19). This claim is supported by key insights from innovation studies and related approaches which underscore that transformation of industry demands not only technological innovations but also 'non-technological innovations – organisational changes, social changes and institutional changes and ultimately system transformation' (Chaminade et al. 2018, p. 89).

The concept of techno-economic paradigms, for example, builds on the idea that radical shifts in technology require a change in organisations, formal institutions and routines in order to lead to large societal changes (Perez 2016). 'New technology systems not only modify the business space, but also the institutional context and even the culture in which they occur'

(Perez 2010, p. 188). In a similar vein, a key proposition made in transition studies 'is that sustainable transitions involve long-term, far-reaching changes towards more sustainable modes of production and consumption in multiple dimensions' (Panetti et al. 2018). The approach focuses on the emergence and diffusion of radical technologies as outcomes of co-evolution and alignment of processes at multiple levels. Technology transitions need to be accompanied with changes in social, economic and institutional dimensions, such as 'changes in user practices, regulations, industrial networks, infrastructure and symbolic meaning or culture' (Geels 2002, p. 1257). Thus, there is a need to understand how changes in industry and 'the wider setting' (Edquist 2005) co-creates industrial transformation.

The view that digitalisation should be seen as being more than development and application of new technology has become popular in the discussion of digital transformation of manufacturing industry, which has received large attention as a key to maintaining competitiveness and jobs (Howaldt et al. 2017). Digitalisation is linked to discussions of Industry 4.0; the fourth industrial revolution that 'describes a new level of organisation and management of the entire value chain across the product life-cycle, able to meet increasingly individualised customer wishes so that even one-off items can be manufactured profitably' (Totterdill 2018, p. 119). Industry 4.0 has the potential to increase firms' competitiveness through reasonably priced, higher quality and customised products and services. However, researchers argue that the discussion of Industry 4.0 tends to be highly technology centred and focused on 'technology push' reflecting a 'one-sided technology-focused understanding of innovation' (Howaldt et al. 2017, p. 50). It is argued that more emphasis should be devoted to how innovation and learning activities are organised in firms, in production networks, clusters etc. Thus, 'digital manufacturing cannot be thinkable without innovation facilitating management concepts and organizational structures' (Howaldt et al. 2017, p. 53), and 'organisations only achieve a full return on investment in technological innovation if it is embedded in workplace innovation' (Totterdill 2018, p. 123).

The focus on workplace innovation is highly important but still insufficient as individual organisations (and production networks) are the centre of interest, neglecting the wider institutional infrastructure. The three types of knowledge and activities providing the basis for digitalisation mentioned above indicate the need for changes in (regional) innovation systems. The development and diffusion of new scientific knowledge may require knowledge organisations with new research agendas or changes in existing organisations, and, for example, also changes in the financing of scientific knowledge production. Development of new digital products and services can, among other things, demand changes in industrial competence and in user behaviour and attitudes. This is demonstrated in the growth of social media, and in regulations, as evidenced through the emergence of Uber. The use of digital technology in existing and new organisations will also require new skills, for example, in automatisation of production processes or in new business models, that is, skills developed in individual firms but also in knowledge organisations like research institutes and universities.

In other words, the creation, adaptation and use of digital technology need support from the knowledge and institutional framework, understood as (regional) innovation systems (Asheim et al., 2019). Regional innovation systems (RISs) are (geographically) open systems, and especially scientific principles that form the basis of digital technologies are to a large extent explicit and globally available. However, parts of regional industry, the public sector and the regional knowledge infrastructure must have the capacity to locate relevant scientific knowledge, acquire, adapt and exploit it – and possibly also contributing to develop the knowledge. This requires changes in RISs; 'radical shifts in technology (technological revolutions) would require a change in institutions, organizations and routines' (Chaminade et al. 2018, p. 21). RISs are, however, first and foremost geared towards backing existing practices in regional industries, for example through the orientation of higher education, research activity and policy instruments. Transformation of existing industry and in particular the growth of new industries meet barriers as long as established sectors and ways of doing things are embedded in (regional) innovation systems that support continual improvement of established activities. Innovation systems with 'strong and durable relationships between users and producers of research results may be beneficial for movement along a trajectory, (while) they may also result in lock-in when there is a radical shift in technological trajectory' (Chaminade et al. 2018, p. 19). It is the case that obstructive regional institutions will hamper industrial transformation (Schamp 2017). Thus, significant use of new digital technology in a region's industry requires changes in the RIS – and since RISs are open systems, their alignment to changes in national and wider innovation systems is also of vital importance. This can mean changes in all parts of the RISs, i.e. in the knowledge infrastructure that develops and diffuses new knowledge, in labour market organisations (e.g. retraining workers), in the institutional framework of laws, regulations, policy tools, and in informal norms and mindsets.

3. Asset modification for digital transformation

A key question concerns the processes that underlie changes in (regional) innovation systems. We address this issue by focusing on modification of existing and development of new assets (or 'capabilities' as denoted by Maskell et al. 1998, p. 53). The idea is that 'digital transformation' of existing sectors and the growth of new digital industries demand that specific regional and extra-regional assets are identified, utilised and, most importantly, modified.

Assets are defined widely to include the institutional endowment of rules, routines, habits, regulations and laws; building and infrastructure; natural resources; knowledge and skills in the workforce and the embeddedness of skills in firm competencies and technology (Maskell et al. 1998, see also Mackinnon et al. 2018a,b). 'These elements are all moulded by historical processes (…) as part of the history of the region or country' (Maskell et al. 1998, p. 53-54). With the exception of natural resources and buildings, these assets are included in the broad definition of RISs (Asheim et al., 2019). Most important for digital transformation is probably developing new competences and skills in the workforce, new firm competencies, new public attitudes and know-how, all supported by changes in the knowledge and institutional infrastructure.

We contend that digital transformation is inextricably linked to complex processes of asset modification. We distinguish between various forms of asset modification, including i) re-use of existing assets (recycling, new use and recombination of existing assets), ii) creation of new assets and iii) destruction of old assets.

Re-use of existing assets may build on *institutional relatedness* wherein firms may 'move into product-unrelated industries if they can make use of non-industry-specific competence, such as how to acquire licences, how to source and finance technology, how to access and leverage relationships with policy organisations, etc.' (Carvalho and Vale 2018, p. 280). Such new use of existing competence resembles technological exaptation (Garud et al. 2016). Exaptation means 'the repurposing of artifacts, technologies, processes, skills, organisations, and resources for emergent uses that they were not (initially) designed for' (Dew and Sarasvathy 2016, p. 167). Sources of technological exaptation are different uses of existing technologies and the co-optation of technologies not yet in use (Garud et al. 2016, p 154). Thus, exaptation regards how existing assets can be applied to other purposes. A mechanism for exaptation is bricolage (Garud et al. 2016, p. 160), which can be defined as 'making do by applying combinations of the resources at hand to new problems and opportunities' (Baker and Nelson 2005, p. 333). Bricolage is a stepwise, bottom-up collaborative innovation process inside organisations and possibly with other (often local actors) which target up-coming challenges in daily work activities. In bricolage 'innovations that start as small intrinsic and interactive adjustments lead to the exercise of new practices and routines' (Fuglsang 2010, p. 74).

The creation of new assets is by definition key to the development of scientific principles that underlie digital technologies. New assets can also be important for the development of digital products and services and for the use of digital technology in existing firms and organisations. Then assets include above all new knowledge among workers, competence embedded in firms and organisations, and laws and regulations that partly protect and partly create markets for new products and services. An example of the latter is how effective demand-side measures at the federal level in Germany have supported the growth of an offshore wind sector (MacKinnon et al. 2018b).

Destruction of old assets is also seen as a mechanism for regional industrial transformation. The reason is that assets may not only form important preconditions for digital transformation but may also hamper transformation processes. This is, for instance, the case when established institutional assets prevent new path development. Thus, 'many of the working and management skills that has been successful in the past become outdated and inefficient, demanding unlearning, learning and relearning processes' (Perez 2010, p. 199).

4. Innovation and new path development

This subsection seeks to shed light on how digitalisation contributes to several types of innovation and forms of path development. Digitalisation initiates process innovations, in particular improvements and simplification of existing work by use of e.g. automatisation and robotisation. Digital tools and equipment can be employed in production processes so that 'a range of innovation outcomes (…) are made possible through the use of digital technologies and digitized processes, the outcomes themselves do not need to be digital' (Nambisan 2017, p. 224). Further, digitalisation may lead to the development of totally new products and services which can give rise to the emergence and growth of new industries in a region that produce for example digital 'hardware' such as robots or drones. It may also lead to altered business models which often include changes in the value chain and new ways to deliver products and services. The business model for production, sales and distribution of music has changed from physical products (CDs) to a subscription (in e.g. Spotify) where all music is widely available (Digital 21). This includes partly renewal of the 'old' music industry, but it also provides the market entrance of new actors with new ways of distribution and sales of music. More generally, digitalisation can contribute to servitization of manufacturing production, that is, 'innovation of an organisation's capabilities and processes to shift from selling products to selling integrated products and services that deliver value in use' (Baines et al. 2009, p. 563). Servitization is a mean for firms 'to move up value chain and exploit higher value business activities' (op. cit.), and is an answer to more complex customer needs and cost-based product competition.

As noted above, digitalisation can lead to innovation based new regional industrial paths, i.e. the emergence of a number of functionally related firms, supportive actors and institutions that jointly contribute to the production of new or renewed products or services, or make use of new production processes, business model etc. for a region (cf. Binz et al. 2016). The literature offers several typologies of new path development (Martin and Sunley 2006, Tödtling and Trippl 2013, Isaksen 2015, Grillitsch et al. 2018, Isaksen et al. 2018a). This paper focuses, firstly, on changes within existing regional industries through *path renewal*, which consists of substantial changes of (and within) a mature established industrial path brought about by the introduction of new technologies, organisational innovations, new business models, and so on. This is in particular linked to 'knowledge type 3' (see above), that is, use of digital technology to upgrade products, services, production processes and business models (Table 1). One example is Internet-of-things, which includes placing sensors in equipment, products, packing etc., and where the sensors are linked to a network that extracts data from the sensors (Digital 21). Internet-of-things allows developing services such as predictive maintenance of products and services.

Digitalisation can also lead to the emergence of new regional industries through path diversification and path creation. This is linked to 'knowledge type 2', which consists of combining scientific and experience based knowledge to develop new products and services. *Path diversification* implies that new industries (with new digital products or services) for a region build on combinations of existing local (and non-local) knowledge and other assets. *Path creation* is the rise of an entirely new industry to a region. The industry can be based on the use of radically new technologies, scientific discoveries or new business models. The new industry may also result from external investments, e.g. through non-local firms that bring in industrial knowledge that is related or unrelated to existing knowledge in the region.

Table 1: Linking of digital knowledge and activities with asset modification and forms of path development

Types of digital activity	**Examples of asset modification**	**Types of path development**
Scientific knowledge that forms the basis for digitalisation	Invention of new scientific principles embedded in research communities	Laying the foundation for various forms of new path development
Digital products and services	Recombination of scientific knowledge and industry-specific, experience based competence	Mechanisms for path creation and diversification
Use of digital products and services in production and work processes	New use of industry-specific competence in order to incorporate digital technology in products, services and work processes	Mechanisms for path renewal

Source: own compilation

Table 1 gives an overview on the key elements discussed above, that is, types of digital activity, modes of asset modification, and forms of path development. It integrates these key elements into a framework that explains how they are related to each other. Table 1 thus demonstrates the links between types of digital activity, system changes understood as (regional) asset modification, and the possible outcomes of these processes, that is, path renewal, diversification and creation induced by digitalisation. On grounds of complexity reduction, examples of asset modification given in Table 1 centre on knowledge and skill assets only. This is not to hide the fact that other assets, particularly institutional ones (as has been discussed above), and their modification are also vital for digital transformation. The paper will now illustrate the applicability of (parts of) this framework by using one empirical example of each of the three types of digital activities.

EMPIRICAL EXAMPLES

The three examples discussed in this section are centred on understanding the type of digital activity in question and on grasping what types of RIS changes (focusing on various types asset modification) are required or result from the digital activity. The discussion of the examples builds on secondary material and a former study carried out by some of the authors of this paper (Isaksen et al. 2018c).

1. Creation of scientific principles

The first example deals with the creation of scientific principles through basic research. Our example is the programme 'IKT Pluss and digital innovation' funded and coordinated by the Research Council of Norway (RCN)[1]. The programme aims to develop strong, robust and internationally competitive research milieus that are at the research frontier within the prioritised topics of the programme. The highlighted topics are big data, artificial intelligence,

[1] Information of the programme is obtained from RCN's project data bank and descriptions of the programme on RCN's web site.

robotics and the internet of things (IoT). The programme is focused on challenge-driven research particularly within the fields of information security, public sector and health.

The programme has funded 316 projects for in total 584 million NOK (about 60 million euros) from 2015 to 2018. However, half of the projects are funded by less than 0,5 million NOK, often to create networks and investigate opportunities for larger projects. Two third of the funds are distributed to universities and research institutes. Most of these are found in two regions; Oslo with the University of Oslo and two research institutes, Simula Research Laboratory and Norwegian Computing Centre; and Trondheim with the Norwegian University of Science and Technology (NTNU) and the research institute Sintef. These five organisations receive 43 per cent of the research funds in the programme. The NTNU campus at Gjøvik and the University of Bergen seize another 15 per cent of the programme's research funds. The faculties of technology, mathematics and science conduct the research at the universities.

These organisations have long-term activity within the research themes funded by the programme. The research activity will then most likely lead to re-use of existing and creation of new assets. One example is the project 'Security in IoT for Smart Grids' run by Faculty of Mathematics and Natural Science at the University of Oslo (UiO). The aim of the project is to create a top international research team on security in the Internet of Things with special focus on smart grid infrastructure. The research partners in addition to UiO are Simula Research Laboratory, Norwegian Computing Centre, NTNU Campus Gjøvik and Department of Technology Systems at UiO, which is located at a technology park outside Oslo. The project collaborates with an applied research organisation, an R&D based consulting company aiming at helping entrepreneurs to grow their firms, and two electric power providers in order for the research to have impact. The project has by 2018 produced 20 scientific publications from its start in 2015, which clearly points to creation of new knowledge.

Health organisations receive 27 per cent of the research funds in the programme, and two third of these funds go to Oslo University Hospital. The largest project at this hospital is 'BIGMED: A big data medical solution for precision medicine'. The project aims to develop new ways of tailoring diagnostics and treatment to individual patients by use of a vast amount of available digital data. The project cooperates with several patient organisations and firms that work to commercialise health technology. The project may lead to new knowledge and also to modify institutions such as laws and regulation. The use of individual data challenges privacy policy, and the project has established a legal group to come up with suggestions on judicial challenges.

Industry has only received about 3 per cent of the programme's research fund which is allocated to 68 projects. A rather large project is 'DigiFab. Automated digitalisation and roadmap to Industry 4.0 for SME-factory'. The project aims to prepare services, tools and methods that support the movement towards industry 4.0 of small and medium sized enterprises. The project cooperates with four manufacturing firms to test and verify methods and has a project group consisting of researchers from NTNU, Sintef, Oslo Metropolitan

University and an independent consultant. This project underpins the impression from the programme about some key research milieus, especially in Oslo and Trondheim, which develop scientific knowledge of digitalisation and which intend to help solve concrete challenges in society and industry.

2. Production of digital products and services

The establishment of Oslo EdTech Cluster may illustrate the development of new digital products and services and accompanying asset modifications and changes in the RIS. Oslo EdTech cluster is a business network established to support the development, commercialisation and export of Norwegian educational and learning technology. This formal cluster initiative was introduced in 2013 by an interest organisation called 'ICT Norway' and the StartupLab at Oslo Science Park in collaboration with several firms and organisations.

The introduction and implementation of learning technology into the education sector has challenged prevailing practices and necessitated a re-use of existing assets. A first step was that teachers on many levels of education acknowledged the technology as an aid towards increasing learning outcome. This included that teachers renew and upgrade their pedagogical references as well as their teaching habits, their technological knowledge, competencies and skills. Thus, Gilje and Ludvigsen (2016, p. xix) find that 'in cases where students work with several different digital tools, teachers will have to spend a good chunk of their time on aiding technical difficulties. Furthermore, they will have to guide students in understanding how to solve the tasks using digital tools'. Another example is the firm 'No Isolation' that has introduced a product that may challenge existing solutions. This consists of a robot with camera, microphone and speakers that can act as a stand-in for sick pupils. The robot acts as the eyes and ears of pupils that cannot be physically present at school, and which may challenge teachers and fellow pupils to rethink what being part of a school class really means.

The introduction of educational technology has also challenged and changed traditional teaching methods. One challenging new teaching method is blended learning, which combines on-campus teaching with digital learning activities. Asset modification is also observed at the firm level. Technological exaptation, i.e. the employing of existing skills, technologies, resources etc. to other than intended use (Dew and Sarasvathy 2016), is observed in several firms. This includes the introduction of game-based learning platforms, tailored chat-interfaces, two ways communication technologies and simulation technology.

The creation of new assets is also observed in the Oslo EdTech Cluster. The introduction of new technologies increased the number of local R&D projects focusing on measuring the effects of digital learning technologies as well as investigating how digital learning technology affects the role of teachers. One example is the R&D project, "Paper and Apps"[2] that introduces new knowledge concerning how paper-based learning tools as well as digital

[2] Authors translation. See http://osloedtech.no/wp-content/uploads/2016/03/arkapp_syntese_endelig_til_trykk.pdf for a Norwegian version of the rapport.

once are chosen and used at several stages of education courses. Further, the EdTech Cluster experienced a significant rise in new member firms, and the Oslo region attracted several new start-up firms, network partners and customers. The Oslo EdTech cluster organisation also succeeded in making EdTech a prioritised area for innovation projects for the period 2016-2019 at the Regional Research Fund for the Capital region (Isaksen et al. 2018c). Thus, new knowledge, firms and policy tools have been created.

Finally, in the Oslo EdTech case, destruction of old assets is also visible. Most evident are changes in the traditional publishing industry where the idea of paper books as being the dominant medium is being replaced by state-of-the-art technological innovations. One representative of such an old publishing house is Gyldendal Undervisning, which has introduced several successful digital technologies[3] like Salaby, Smart Øving, Smart bok, and Smart tables.

3. Utilisation of digital technology

An example to illustrate the utilisation of digital technology is the industry cluster iKuben. iKuben is a cross-industry cluster located at the Western coast of Norway. It consists of 47 partners ranging from research institutes and municipalities to manufacturing firms. The firms are mainly focused on engineer to order (ETO). When they initially applied for becoming part of the Norwegian cluster programme, 'Norwegian Innovation clusters'[4], the members sought to find areas of possible collaboration overarching all the different industries. At first, the cluster focused on material technology, logistics and innovation, before changing their focus to digitalisation and industrial Internet.

Today, the focus of the cluster is to *'help companies to utilize digital knowledge to create new products, services and business models'*[5]. According to a respondent from Ikuben (interviewed in January 2017), the cluster organisation does not view digitalisation as merely a tool for increasing efficiency, but rather as a way for companies to learn about new technologies, build new products and services and earn money. This is the rationale behind iKuben's focus on business models. As stated by a respondent from the cluster organisation in January 2017, *"our firms are also interested in robotization, automatization, 3d modelling etc. but we cannot as a cluster build special expertise across the whole field. Therefore, our competence is to be at the last stage of the value chain, commercialisation, business models etc."*

Working on digitalisation, and the potential it holds for each firm in the cluster, has created a need for *modification of regional assets.* iKuben has worked on increasing the competence of the cluster firms regarding digitalisation. One way of increasing the competence level has been to create a continuing education programme about 'innovation and industrial internet' at

[3] Source: http://osloedtech.no/medlemmer/
[4] http://www.innovationclusters.no/english/
[5] http://ikuben.no/om-ikuben/

the local Molde University College. Some of the funding for this programme comes from the public support system received by iKuben. In addition, the university college also develops courses and seminars tied to these themes.

In order to utilise new digital products or services, iKuben, in collaboration with Molde University College, created an innovation lab called ProtoMore. The aim of this lab is to challenge the firms' mindset, for example regarding digitalisation, and for them to come up with new ideas for products or services and develop business models. ProtoMore is an example of creation of new regional assets of both tangible and non-tangible nature. Firstly, it is a physical space where companies can work to realise ideas through testing of prototypes, and, secondly, the lab has also created their own methodology.

The new way of thinking about industrial development and business model that is being taught at Molde University College illustrates the significance of destructing old assets. In addition, the destruction of old institutional assets has been important for iKuben. For a long period of time, iKuben struggled to become a Norwegian Centre of Expertise (NCE) in the Norwegian cluster programme. The struggle was, according to our respondents, due to the institutional set up of the cluster programme in Norway that primarily focuses on one industry clusters as opposed to cross-industry. One cluster member said that they demanded an evaluation of the criteria for becoming an NCE. Whether it was iKuben's persistence that was the contributing factor or not, the programme ended up being evaluated, and some iKuben members feel responsible for promoting change or destructing the old institutional assets. The former single industry focus from policymakers can arguably be viewed as having hampered the development of iKuben.

The three examples demonstrate that the theoretical framework (Table 1) that links three different types of digital activity to asset modification and RIS changes has analytical potential. All examples show that digital activity requires reusing of existing assets and the creation of new assets, such as new or modified knowledge and skills, but also new organisations (e.g. a prototype lab), new norms (about teaching methods), new policy priorities and new education programs. Examples of destruction of old assets (e.g. understanding of the cluster concept) are also observed. What is currently missing is to better link the three digital activities empirically and theoretically, e.g. examination of what scientific knowledge underlies the development of digital products and services and in what way knowledge and digital products and services contribute to digital production and work processes.

CONCLUSIONS

Regions across the world are confronted with substantial transformation challenges emanating from the rapidly increasing impact of digital technologies on society and economic growth. This paper seeks to develop a novel conceptual approach for analysing wide-ranging 'digital' transformation processes of regional industries. We build on emerging research perspectives (in particular systemic, multi-actor and multi-scalar approaches, broad views on assets and a differentiated view on path development) and integrate them into a comprehensive framework that provides a nuanced understanding of regional restructuring induced by digitalisation. Our framework clearly challenges standard EEG models, which advocate firm-based views, propagate skill relatedness and emphasise local processes in their explanations of how regional industrial change takes place. We offer a more comprehensive conceptualisation of regional path development and apply it to digital transformations of regional economies and industries.

We differentiate between three types of knowledge and activities that are vital for developing, employing and diffusing digital technologies. These include i) development of scientific principles that constitute the building block for developing digital technologies; ii) scientific and experience-based knowledge that allows for producing digital products and services, and iii) knowledge of how to apply digital products and services in established and in new production and service activities and work processes. Our framework helps to disentangle how these different types of digital activities are linked to system changes conceptualised as asset modification and how this might lead to or result from various forms of path development activities in regional economies. System changes are seen as vital for digital transformation to unfold. This is because we appreciate that established (regional) innovation systems may form environments that not only facilitate but also constrain the renewal of mature industries and the rise of new economic activities. We suggest interpreting system changes as processes of asset modification, distinguishing between re-use of existing assets, creation of new assets and destruction of old assets.

The paper has examined three empirical Norwegian cases to illustrate and test our framework. While the review and critical discussion of the empirical material has largely confirmed the value of our approach, it has also shown that further conceptual work needs to be done to improve understanding of the ways by which asset modification is linked to digital transformation, that is, how re-use, creation and destruction of assets are combined in processes of path creation, diversification and renewal. Empirical evidence suggests that all three types of asset modification matter for all forms of path development considered in this paper. What remains less clear is the relative significance of different types of asset modification and their particular ‘mixes’ in the ‘digital renewal’ of mature sectors and the rise of new digital industries through path diversification and creation activities. Further, geographies of asset modification underpinning digital transformation require more attention in future analyses to gain deeper insights into what is local and what is non-local in new path development triggered by digitalisation.

There is also a need to analyse how the three digital activities outlined in Table 1 are linked. This may include studying what type of scientific knowledge provides the basis for digital products and services and in what ways, and how such products and services are used in specific production and work processes. Finally, future studies might seek to employ an agency perspective to highlight the ways by which asset modification is performed by multiple ‘pioneers of digital change’. Recent work on firm level and system level agency

(Isaksen et al., 2018b) could serve as a point of departure to explore how agency is shaping asset modification for system transformation and new regional industrial path development. These issues call for further conceptual advances and more in-depth empirical investigations in various geographical and industrial contexts. Exploring how digital transformation unfolds in different types of regions (and industries) with different asset endowments and varying capacities to modify these would bring further insight into why some places (and industries) are at the forefront of digital change while others fail to adapt to new challenges.

Finally, our conceptual approach provides a basis for carving out some key policy implications. Recent contributions highlight that digitalisation and other grand social challenges are often complex as they cross various policy areas, public, private and voluntary (third) sectors and need to involve a diverse set of actors besides industry. 'Such complexity calls for a systemic approach' (Edler and Bonn 2018, p. 433), 'requires continuous adjustments and reflexivity among several involved stakeholders' (Bugge et al. 2018, p. 468) and active governance. The framework advocated in this paper complements these insights, drawing attention to the various types of digital activities and different forms of asset modification that should be supported by 'systemic policy approaches' and collective agency performed by multi-actor governance constellations.

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Department of Geography and Regional Research
University of Vienna

Contact person: Michaela Trippl
Universitätsstraße 7/5/A0528, 1010 Vienna, Austria
Tel.: +43-1-4277-48720
E-Mail: Michaela.trippl@univie.ac.at
https://humangeo.univie.ac.at/

Department of Socioeconomics
Vienna University of Economics and Business

Contact person: Jürgen Essletzbichler
Welthandelsplatz 1, 1020 Vienna, Austria
Tel.: +43-1-31336/4206
E-Mail: juergen.essletzbichler@wu.ac.at
http://www.wu.ac.at/en/department-socioeconomics

Institute for Urban and Regional Research
Austrian Academy of Sciences

Contact person: Robert Musil
Postgasse 7/4/2, 1010 Vienna, Austria
Tel.: +43-1-51581-3520
E-Mail: robert.musil@oeaw.ac.at
https://www.oeaw.ac.at/en/isr/home/

Department of Working Life and Innovation
University of Agder

Contact person: Arne Isaksen
Jon Lilletunsvei 3/A161, Grimstad, Norway
Tel.: +47-37-23-33-53
E-Mail: arne.isaksen@uia.no
https://www.uia.no/en/about-uia/faculties/school-of-business-and-law/department-of-working-life-and-innovation

Department of Geography
Kiel University

Contact person: Robert Hassink
Hermann-Rodewald-Str. 9, 24098 Kiel, Germany
Tel.: +49-431-880-2951
E-Mail: hassink@geographie.uni-kiel.de
https://www.wigeo.uni-kiel.de/en/