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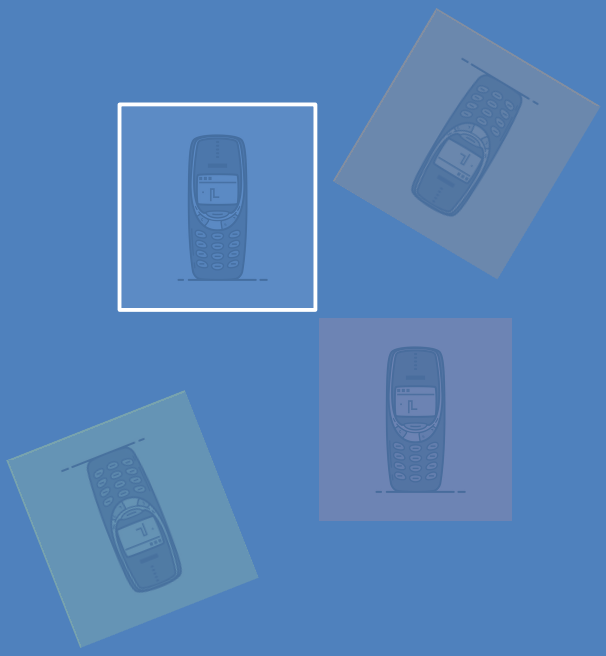
Path development and constructed regional resilience

The case of the Nokia-led ICT industry in Tampere



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1 Introduction

Tampere is Finland's second-largest city-region after the capital region. Still, from the European perspective, it is at most a middle-sized city located in the far north. In this respect, it is intriguing that Tampere was a key location when the Nokia corporation entered an era of tremendous growth due to its digital mobile innovations. Tampere became a part of this success story, partly because of its strong educational and research basis and its ability to grow in tandem with Nokia's expansion, especially in the mobile phone business. The local economic and innovation policies were also geared to supporting this line of development.

However, Nokia's glorious rise and the era of dominance of more than decade underwent an epic decline when Microsoft acquired and eventually terminated Nokia's whole mobile business, resulting in thousands of redundancies and lay-offs in Tampere, alongside a wholesale change in the ICT industry. Fortunately, the ICT industry seems to be experiencing a new upsurge. At the same time, the way to conduct local development policies has evolved, having an effect on research and education. Furthermore, there are signs that different stakeholders have been able to strengthen the resilience of Tampere.

From this point of departure, the main aims of this paper are (1) to examine how the different development phases of the local ICT industry are connected to the evolution of its resilience capacity, (2) to analyse the 'constructed resilience', i.e. the intentional measures to strengthen the resilience capacity and (3) to scrutinise the role of universities in relation to the development stages of the industry. This paper argues that resilience is not a predefined character of a city and that it can be developed through strategic, collaborative measures

In this paper, case methodology is applied and various sources of data are drawn upon. The main body of the empirical data consists of standard statistics (Statistics Finland); 73 daily paper articles (93 pages from *Aamulehti*, the main local newspaper); six extensive, thematic face-to-face interviews; and two thematic group interviews. In addition to these sets of data, other written and electronic materials are used.

2 Setting the scene[1]

2.1 The roots

Founded in 1779, Tampere is Finland's second-largest city-region after the capital region. Its population totals approximately 380,000. Tampere has a long industrial history, and it can even be claimed that the industrialisation of Finland got under way in Tampere. The main industrial forces of Tampere were the cotton mills and paper factories. Later, this industrial base expanded to include the textile industry and mechanical engineering, among others (see

[1] This chapter is partly based on Kolehmainen (2003) but the description has been updated and revised.

Haapala 2005). The smoke-stack industries formed the basis of economic development until the 1990s, when Finland was hit by a deep recession. This was a turning point in the development of the industrial structure. Since then, the strategy of Tampere has been to modernise traditional industries and to develop new high-tech industries (Kostiainen & Sotarauta 2003).

In less than a decade, Finland moved from being one of the least ICT-specialised countries to one of the most specialised, in terms of exports, production and research and development (R&D) (Boschma and Sotarauta 2007). The extremely rapid shift of Finland to a knowledge-based economy involved many coincidental factors and good timing. Although the pace of change accelerated in the 1990s, the foundations for the emergence of the ICT cluster were already laid in the 1900s. Early and strong competition (including the presence of foreign companies, such as Ericsson and Siemens), demanding customers (network operators), standardisation (Nordic Mobile Telephone Standard) and a culture open to new technologies contributed significantly to the evolution of the ICT cluster. The business sector, of course, played a key role in the cluster's development, but the institutional setting and public policies have also been major factors (Boschma and Sotarauta 2007: 169). Geographically, the main locations of the Finnish ICT cluster were Helsinki, Tampere and Oulu.

In the early 1990s, there was only a clutch of separate ICT-related companies in Tampere. After that, the agglomeration grew very rapidly. In 1996, the ICT agglomeration consisted of approximately 170 companies and business units, with a total of 5,200 employees and a total turnover of about 770 million euro. In 2000, total turnover had doubled, amounting to 1.5 billion euro. The rapid development of the agglomeration resulted largely from the natural, rapid development of the ICT sector. For example, the 'Internet revolution' in the mid-1990s generated new media business, which thereafter transformed drastically. Most of the ICT-sector growth was Nokia-led in the Tampere region. In addition to natural growth, ICT has been one of the most important focus areas of local (business) development, innovation and higher education policy in the Tampere city-region. (Kolehmainen 2003)

2.2 Higher education institutions

The strong science and technology base and the educational institutions have been major strengths of the ICT cluster in Tampere. The most important institutions in this respect are the Tampere University of Technology (TUT), the University of Tampere (UTA) and Tampere University of Applied Sciences (TAMK). TUT has traditionally had very close relationships with local businesses, both in terms of research and education. In terms of research, TUT has had several fields of research that have contributed to the ICT industry (e.g. digital signal processing, computer science, software systems). ICT-related education and research began to strengthen in the 1980s, when computer science became a major subject at TUT. Since then, the volumes of information, communication and electro-technical education and research have grown very rapidly. In the late 1990s, there was a dramatic increase in ICT-related higher education and

research nationwide and Nokia was naturally a central player in this respect (e.g. Häikiö 2002: 91-93).

UTA has its roots in the social sciences, but today it is a diversified university with approximately 11,900 first-degree students and 1,700 post-graduate students. Despite its emphasis on the social sciences, UTA also has long traditions in computer science and other ICT-related fields of education and research. UTA started teaching activities in computer science in 1965, the first ever in Nordic countries. At the moment, the majority of the ICT-related subjects are studied in the Faculty of Communications (COMS). Human–computer interaction is a very important area of research and there is even a separate Tampere Unit for Computer-Human Interaction (TAUCHI) for this purpose. Correspondingly, there is a long tradition in digital game research at UTA (Kolehmainen 2003).

TAMK completes the operations of the two universities in Tampere. It is oriented towards working life and RDI collaboration. TAMK is one of the most popular universities of applied sciences in Finland and has quite a strong focus on international education. Its diversified teaching activities support in many ways the development of the local ICT cluster, although it is smaller than the two universities. Currently, TAMK has about 10,000 students and 720 staff members.

2.3 Regional development agencies

ICT industry has been one of the key areas of local business development and innovation policy in Tampere for more than two decades. ICT was one of the new industries that emerged when the traditional smoke-stack industries waned. Although the basic technological knowledge and other competences of the industry lie in companies, higher education institutions and research institutes, competent business support, development and intermediation organisations can harness these competences to better use and even participate in the process of creating new regional competences and governing the local economic restructuration.

In the Finnish context, there are several public agencies working together to boost local economic development. First, local government, i.e. cities and municipalities, is very strong from the European perspective. For example, the regional councils are owned by the cities and municipalities of each region, even though they serve as general regional development authorities. The regional councils were established in 1994; there are 18 in Finland. In recent years, the Council of Tampere Region has become very active in respect of local and regional innovation policy and has promoted open innovation, multidisciplinary innovation platforms and user-driven innovation. In addition, it is coordinating regional foresight activities.

On the other hand, the cities and municipalities have set up several voluntary organisations related to economic development on their own or with other actors. Tampere has many intermediary organisations that have been concerned with stimulating the emergence of a strong knowledge-based ICT sector with collaborations between HEIs and firms. Firstly, its local government is very strong, with a strong city government but also a regional council (general

regional development authorities owned by regional cities/municipalities). Tampere Region council has become very active in innovation policy promoting e.g. innovation platforms and user driven innovation. The national state owns Centre for Economic Development, Transport and the Environment (ELY Centres) in Tampere offering a wide range of economic development activities, including business support and employment services (advisory, training and expert services and funding for investment and development projects etc.). ELY Centres also administer Tekes (the Finnish Funding Agency for Innovation) services in the region. The regional councils and ELY Centres will be amalgamated in 2020.

Cities and municipalities have also set up their own economic development organisations and networks. Tredea Ltd. or 'Business Tampere' (Tampere Region Economic Development Agency), was started in 2009 by the eight municipalities of Tampere city-region. It provides support to start-ups and potential inward investors and is active in the execution of international talent attraction activities. All the activities have been very important during the dramatic restructuring of the ICT industry. Hermia Group is more focused, established in 1986 as Tamlink, offering specific product development and innovation services through one of its two subsidiaries, being Finland's oldest technology transfer company linked to TUT both operationally and via ownership. The other subsidiary - Innovaatio Oy Uusi Tehdas Ltd - stems from the Tampere Technology Centre which was established in 1990 to develop the Technology Centre Hermia founded four years earlier (see Lehtimäki 2005).

3 Path creation and path extension in the Tampere region

3.1 Path creation: Roots grew into mature business

To place the ICT cluster development in Tampere into a theoretical framework, we can say that Tampere was creating its ICT path in the 1990s. Path creation can be described as the 'establishment of new firms in new sectors for the region or firms that have different variants of products, employ new techniques, organize differently, etc. than what hitherto have dominated in the region' (Isaksen 2015: 588). These industries can be either new to the region or entirely new industries (Tödtling and Trippl 2013), as in the case of Tampere. Innovations, knowledge base, investments and structures created in the 1990s laid the basis for a new mobile industry that started to grow rapidly.

Path creation usually has two main streams: it may be caused by inward investments and/or sectoral diversification of existing firms through path branching, or it can be research driven, focusing on the commercialisation of research results (Henning et al. 2013: 1353). In Tampere, we can see both of these paths. Nokia was an existing company that enlarged its product scale but there was also a strong contribution from basic research. Nokia was tightly integrated into the local research ecosystem in the 1990s. TUT had an important role in exper-

imental basic research, standardisation and innovations that led the way to modern mobile technology, such as the development of the digital signal processing needed in mobile phones. As mentioned earlier, the volume of education, especially at TUT, grew very strongly in the late 1990s. In addition to an increasingly diverse basic-degree and post-graduate education, TUT also offered in-service training and supplementary education for companies. Some of these courses have served as important networking forums for local ICT professionals (Kolehmainen 2003). Path creation may also require the building of new knowledge organisations and institutional change (Tödling and Trippl 2013). We can see the establishment of Finland's oldest technology transfer company (Tamlink) and the later Hermia Group as an example of building such institutional capacity in the Tampere region since the late 1980s.

In the beginning of the 2000s, the basic structure of the ICT cluster had matured somewhat. The business structure of the cluster was largely dominated by the business units of large, international ICT companies, such as Nokia, TietoEnator, Sonera and Fujitsu Invia. Nokia Corporation was the backbone of the whole cluster for a long time and its story will be dealt with in detail later. In any case, the ICT cluster was and still is oriented towards R&D, a concern also of the above-mentioned business units of large companies (Kolehmainen 2003).

The large companies were extremely important employers, especially in the later 1990s and early 2000s, but the dominant role of those companies had negative side effects as well. For example, one of the major weaknesses of the ICT cluster was a debilitated entrepreneurial atmosphere, which was linked to the paucity of (new) companies aiming at fast growth and internationalisation (cf. Autere 2000). This feature was particularly striking at the end of the 1990s, when the ultimate 'IT hype' occurred in Finland and many new companies with reckless objectives were founded. On the other hand, Tampere survived quite well in the first 'IT recession' at the beginning of the 2000s when the 'dot.com bubble' burst (Kolehmainen 2003). The restructuration of the ICT cluster took place almost a decade later.

3.2 Path extension: From the ultimate boom to the first worrying signs

The global success of Nokia mobile phones in the early 2000s created a positive circle. There were no doubts, however, that this state might not last forever. This eventually led Tampere into **a path extension**, 'in which increasing returns and positive externalities reinforce local industrial dynamism' (Martin and Sunley 2006: 415). In path extension phase, success is based on incremental innovations in the existing industry (Hassink 2010a). This was also the case for Nokia and Tampere as they started to repeat the patterns of their success based on mobile technology. Established ways of doing things started to emerge. The logic of 'increasing returns' and 'positive lock-in' started to take place. Both of these concepts refer to a state in which the current circumstances receive positive feedback and seem productive. This leads to a self-reinforcing circle (Arthur 1989: 127; Martin and Sunley 2006: 401-402).

Interviews conducted in the Tampere region confirmed the existence of both formal and informal established patterns of practice. TUT in particular created a special relationship with

Nokia. Visible manifestations of co-operation were student and graduate recruitment to Nokia, thesis subjects, the indirect effects on TUT's course contents, strong personal connections and project funding from Nokia. In some years, almost complete classes of graduates were recruited by Nokia from the study programme of Electronics and Communications Engineering. The special relationship with Nokia was very useful for TUT at this stage because Nokia was a stakeholder and a co-funder in almost every research project. With its global connections, Nokia also contributed to TUT's internationalisation process. At this point, co-operation had matured to its fullest state. TUT 'didn't need anyone else' and they were 'looking at the world through blue Nokia glasses'. Consequently, the Nokia dominance damaged TUT's other connections with local businesses to some extent.

The setting in Tampere and TUT started to change. With its global resources, Nokia was the research leader in communications technology. Over time, TUT became a follower that provided qualified labour resources. Nokia started to focus more on product development than on basic research, which had originally been important in the collaboration with the university. Engineering students were not excited about entrepreneurship because Nokia offered attractive job opportunities. Still, Nokia was not that strongly embedded in the local development system. It had its own strong global Nokia community, networks and processes, characterised by a closed and traditional innovation process. Nokia also had a positive but distant attitude towards regional development initiatives, such as the eTampere Programme, an ambitious policy programme established by the city council to develop the local information society and digitalisation in the early 2000s. There were also some other weak signals of the weakening embeddedness of Nokia in Tampere. For example, most of Nokia's site managers in Tampere were not very visible in the regional development networks despite the huge economic role that Nokia had in Tampere. It also worried some policy-makers that Nokia did not own its business premises in Tampere, but that may have been the case at least partly due to the huge growth.

Despite some warning signals, this regional economic lock-in situation could be described as a positive lock-in at the beginning of the 2000s because it was still beneficial to everybody. According to Martin (2012: 12), regional economic resilience consists of a region's ability to resist recessionary shocks, its ability to recover, its ability to renew a growth path and its ability re-orientate. Regional resilience in the Tampere region was quietly deteriorating, however, because of the increasing dependency on one significant player that was, after all, quite passive in its local business community. Paradoxically, from the local policy-making view, Nokia was at the same time everywhere and nowhere.

4 Path exhaustion: Considerable structural changes

4.1 Mobile phone businesses of Nokia and Microsoft hit the wall[2]

The engineering industry, especially mobile phone technology development, had transformed the industrial scene of Tampere over the 1990s and the industry kept growing until the global economic downturn in 2008. The story of Nokia Ltd., the Tampere region and all of Finland as a cutting-edge knowledge economy are closely intertwined. The role of Nokia in the development of economic and innovation systems in Finland has been vast. In 2000, Nokia held a 40% share of the world's mobile phone market. In the top year, 2000, Nokia alone produced 4% of Finland's national GDP. From 2001 to 2007, the share varied between 2.9 and 3.8%. Nokia accounted for approximately one-third of total Finnish R&D expenditure (2008) and a share of exports of over 20% (2000–2002). Nokia's impact on Finland's GDP decreased dramatically after 2007, however, and was even negative in 2012. This drop naturally had large-scale effects on the Finnish economy, employment and exports, as well as on the cities where Nokia had its facilities (Ali-Yrkkö 2010; Ali-Yrkkö, Seppälä and Mattila 2016).

Until 2008, the development of the whole ICT industry in Finland, including Tampere, was quite steady and positive. The first visible changes in the structures of the ICT sector of Tampere occurred at the same time as the global economic crisis began. The amount of open ICT vacancies started to decrease. On top of that, in 2009, Nokia started to reduce its people by offering 'voluntary separation packages'. These were the first signs that Nokia's mobile business was facing major trouble. Those who were working in Nokia in strategic positions saw that the outlook was anything but good. At the time, a quite substantial number of Nokia's employees started to look for new challenges. Eventually, Nokia laid off a few hundred people over the next two years, but that was just the beginning.

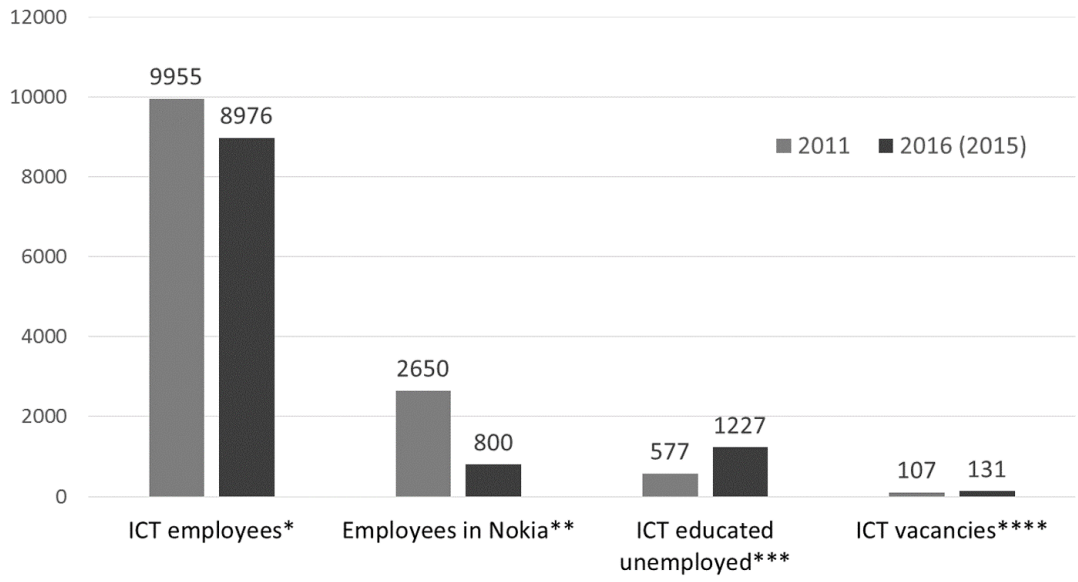
The radical measures began in early 2011, when Nokia and its new CEO, Stephen Elop, started to make strategic changes. To compete with the successful Apple iPhone, Nokia chose a new technological platform, the Microsoft Windows Phone, for smart phones and gave up developing Symbian- and Linux-based technologies. In the new situation, many of the experts were found to have inadequate technological competences. This shift can be seen as the turning point, after which it was widely recognised that major changes were going on in the ICT business of Tampere. Unfortunately, the new Windows phones flopped in the market. Over the next four years, Nokia and Nokia Siemens Networks had several redundancy cycles; they also outsourced people to other companies, such as Accenture. These actions concerned a couple of thousand people in Tampere. At this point, it was self-evident to everyone that the ICT industry had been far too dependent on one giant, Nokia. The way out was rough.

[2] We have compiled the milestones of Nokia-related events from the news archives of the local daily newspaper *Aamulehti* and from regional employment authorities' reports (Salkoaho 2015).

Finally, in 2014, after a struggle of three years, Nokia announced that it would sell its mobile phone business to Microsoft and concentrate on network solutions, location services and technology licencing. Staff members in mobile phone development were transferred to Microsoft. Two more years with constant struggle against falling market shares and huge economic losses were ahead. Then, in 2016, Microsoft announced that it would be ending its production of Windows phones completely. This was the final blow for the mobile phone industry of Tampere, where 500 ICT jobs disappeared. I what follows, we will have a closer look at the structural changes and the dimensions of the regional lock-in.

4.2 Structural changes in the ICT sector of Tampere

The total unemployment rates in Tampere and the surrounding Tampere region have been above the national average since 2007 (Statistics Finland 2016). The city of Tampere had the highest unemployment rate of the six largest cities in Finland (City of Tampere 2016). There were close to 4,000 employees in Nokia Ltd and Nokia Siemens Networks in 2009 in Tampere, and Nokia was the biggest employer in the region (City of Tampere 2011). In Figure 1, we can see that this number had fallen to 2,650 people by 2011 and 800 people by 2016. The share of the whole ICT sector was 8.7% of all employment in the Tampere region (for Finland it was 6.3%) in 2009, falling to 7.0% (Finland 5.6%) by 2015. Despite this decreasing share, the relative significance of the ICT sector is great in Finland as a whole and even greater in Tampere and the Tampere region. The loss of ICT jobs has also had indirect effects on employment in other sectors because they provided services for the ICT business.



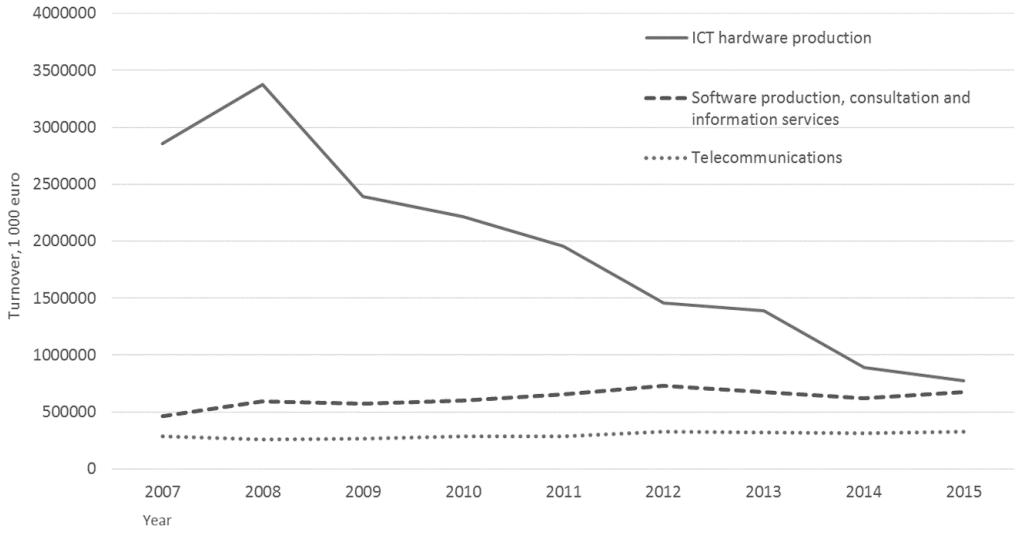
* Statistics Finland (2016), Statistics Finland (2013)
** 2011: Tampere Chamber of Commerce (2012:2), 2016: Aamulehti (2016)
*** 2011 May and 2016 September by Neittaanmäki & Kinnunen (2016:9)
**** Ministry of Employment and the Economy, Sector Online (2016)

FIGURE 1. Some aspects of the ICT employment changes in the Tampere region.

In the Tampere region, the total number of ICT-sector employees has decreased and unemployment has increased (Figure 1). In 2011, the ICT sector employed nearly 10,000 people. Five years later, the jobs of 3,000 people had been restructured. About 40% of these people were re-employed relatively quickly, 40% were engaged in subsidised activities (coaching, retraining, entrepreneurship courses) and 20% were in danger of long-term unemployment (Salkoaho and Ikonen 2015: 8). Unemployment has been structural and problematic among those people who have only a secondary-level vocational education; they form two-thirds of unemployed ICT-educated people. New vacancies require high-level technology competences. Unemployed middle management is another group that is facing challenges in finding new work (Neittaanmäki and Kinnunen 2016: 21).

The ICT sector has been going through a structural change. Redundancies in the mobile sector are only one aspect of this development. A new wave of software small and medium enterprises (SMEs) and a few larger actors have emerged. In addition, ICT specialists are being employed by the more traditional industrial sectors, which have been going through a transformation in the direction of utilising smart technologies. During the recession, many ICT enterprises have been recruiting specialists constantly. Their message has actually been that they need a greater number of skilful software developers. Many of the new vacancies are created by SMEs, who are recruiting technical and sales specialists rather than the middle management that was a large group in Nokia. There is a great need for the updating of technological skills through supplementary education. Moreover, some international companies have seen their chance to recruit skilful labour and have established units in Tampere (e.g. Intel, Huawei). Once again, there seems to be a deficit in technological experts, especially in the software business (*Aamulehti* news archives). Nonetheless, the existing ICT companies in the Tampere region are growing. In 2016, they estimated that altogether they would recruit over 700 new people. Among the companies implementing recruitment programmes of approximately 100 people are Solita, Vincit, M-Files and Gofore (Tampere Chamber of Commerce 2016: 19). The coexistence of unemployment and numerous unfilled vacancies suggests that there is a mismatch between labour supply and demand.

In addition to the changes in the local labour market, the restructuring of the Tampere ICT cluster becomes visible in the changes in companies' turnover, the focus of industry and the establishment of new companies. The overall turnover volume of current ICT companies in the Tampere region is still low compared to the volume of the Nokia days (Figure 2).



Data source: Statistics Finland 2016

FIGURE 2. Turnover development of the ICT sector in the Tampere region.

The business structure of the ICT industry in Tampere and the Tampere region has also changed. There are more SMEs and the focus has moved from hardware production (mobile phones) towards software development. The number of ICT companies or their local units has grown from 720 to 859 between 2007 and 2015 (Statistics Finland 2016). Exports, which used to be a strength in the Tampere region, have been low for several years and have recovered rather slowly. The challenge is to internationalise the growing software field and make a shift from exporting consumer goods to immaterial services. The new ICT business is versatile and a lot of potential is identified in the games industry, web applications, cloud solutions, cyber safety, health technology, location-based services and the digitalisation of all kinds of services and traditional industry (*Aamulehti* news archives).

Universities in Tampere experienced the effects of ICT restructuration, as described by the interviewees. Students were no longer so interested in applying to study the programme in Electronics and Communications Engineering at TUT and intakes were reduced. By contrast, electrical energy engineering has grown in popularity. The contents of study programmes were not notably altered, however. TUT faced a situation where external funding diminished considerably. For years, Nokia was the most significant research partner. Ongoing projects lasted for a couple of years, which gave time to adjust to the new circumstances. Competition for funding sources became more intense. TUT started to reach out to new project partners and opened up to a new kind of collaboration. The new wave of ICT companies has had a more open approach to co-operation; for example, companies have been interested in utilising students as an innovation resource.

4.3 Dimensions of the regional lock-in in Tampere

Next, we will outline the reasons behind the rapid changes in the Tampere region. To put the development into the framework of path dependency, it can be said that Tampere was driven into a state of lock-in. The success of Tampere was closely connected with the mobile phone industry and this regional path encountered rapid exhaustion. Hassink (2010b) describes **path exhaustion** as a state in which the innovation potential of local firms has been reduced or innovations are restricted to a specific technological path; regional industry has low adaptability with regard to technological and market changes. Martin and Sunley (2006: 415) describe lock-in as a situation in which a technology, industry or regional economy has become stuck in a particular trajectory or path that has become inefficient in some way.

Because Nokia was the most significant single factor in shaping the ICT cluster in Tampere, we take a closer look at the principal reasons identified for its decline. Laamanen et al. (2016: 13-17) have analysed the discourses around Nokia's failure. They outlined four categories that were identified as problems: (1) wrong strategic choices (e.g. technology, timing, people in leading positions, neglect of innovations and products that could have been triumphant); (2) lack of the capabilities to face new challenges; (3) organisational design (e.g. inflexibility, structures that prevented efficient R&D); and (4) environmental factors, such as changes in the market and the economic downshift.

According to the interviews, the ICT industry in Tampere shared similar problems: it as unable to understand market requirements and compete with iPhone; Nokia's organisation became too massive, bureaucratic and slow; Nokia had a traditional innovation process; and the globally difficult economic situation. A larger context was also delineated: 'The time of the dinosaurs was over', 'It was time for new and more agile companies' and 'creative destruction'. We can see correspondence here with the attributes of path exhaustion and organisational-level reasons for failure. What happened with Nokia's organisation was intertwined with the path of Tampere, although the effect was mostly one-way. In the local context, there were no instruments to intervene in the global company's choices or significantly help it to overcome difficulties. In the regional context, by contrast, the global company had a large effect.

On the regional level, lock-in can be seen from many different perspectives. Martin and Sunley (2006: 400) summarise the aspects of path dependency: (1) technological lock-in; (2) dynamic increasing returns, in which positive feedback reinforces existing paths; and (3) institutional hysteresis, in which formal and informal institutions, social arrangements and cultural forms self-reproduce themselves. Interviewees saw that the external forces (like Nokia's situation and the global economic conditions) were not the only reason for the problems of the ICT business in Tampere and that regional actors played their own role. Technological lock-in can be seen at the regional level in the highly specialised labour. Competences in mobile technology were high but narrow. Dynamic increasing returns encouraged different actors, such as the city and the universities, to invest in Nokia-related development because it was economically beneficial. Regional actors failed to build a larger industrial basis in the ICT sector and relied

too much on one pillar. Institutional hysteresis can be seen in Tampere as well. For example, there were established forms of university–Nokia collaboration and behavioural patterns, such as the engineering students' obvious career paths to Nokia. People working in Nokia also had limited personal networks that did not integrate with the other local industry networks. Regional resilience was not constructed as systematically as it could have been.

The literature on regional lock-ins usually focuses on old and mono-structural industrial regions (Hassink 2010b). The case of Tampere is exceptional because it is an example of transformation occurring in the information age. Changes in new, knowledge-intensive industries can be very fast. In Tampere, restructuring took place rapidly and in a crisis. David (2001: 26-27) suggests that sometimes, when endogenous development ceases, an external shock is required to shake the region out of its lock-in. Martin and Sunley (2006: 406) see this as an overly radical interpretation and it is true that such a shock is not always needed. In Tampere, it cannot be said that endogenous development would have totally ceased but it may have been interrupted. The de-locking process was rough but necessary. One development manager in the city of Tampere even said that 'Nokia and Microsoft downsizing and shutdowns were the best things that have happened to Tampere after all'. Simultaneously, as one path was coming to an end, new paths were already starting to emerge. New ICT SMEs were established and the old machine industry was modernised from the inside. Next, we look at the procedures that were launched to help the restructuring of the ICT sector in the Tampere region and to consciously construct regional resilience.

5 Path branching by deepening, open collaboration

5.1 Actions before the crisis

Not all of the actions to reshape the industrial scene of Tampere were reactive responses to the immediate crisis. A lot had already been done to promote innovation and SMEs in the years 2008–2009. Innovaatio Oy Uusi Tehdas Ltd. was running its 'New Factory' in the historic heart of Tampere. This was a business incubator and an innovation centre or platform that aimed to 'connect entrepreneurs, students, researchers, mentors, investors and experts from various fields into value co-creation'. In this respect, a concept called 'Demola' has become quite prominent. Established in Tampere in 2008 and now operating in 13 locations worldwide following convergent operating principles, Demola is a student innovation project platform on which multidisciplinary and often multinational student teams solve real-world challenges provided by companies and other organisations. The results of these projects are concepts, demonstrations and prototypes. The striking feature of this concept is that the student teams remain the immaterial property owners. Thus, the teams can benefit from their work not only as academic credits and experience but also financially. The teams may even establish their

own start-ups. Because Demola is linked to students and studying, in Tampere, TUT, UTA and TAMK, together with city of Tampere, have become the actual owners of Demola activities.

The New Factory is also a start-up incubator or accelerator for beginning entrepreneurs. The results of the New Factory are quite impressive; more than 160 established start-ups, 1,600 jobs created and 35 million euro in raised funding. The roots of the New Factory's start-up activity are in the so-called 'Protomo' concept, which was established in 2009. The key idea was to facilitate the birth of new start-up companies by bringing together newly graduated university students and highly educated unemployed people, such as people laid off from Nokia. The idea was quite explicitly to govern the structural change of the local economy and to alleviate its negative consequences. The first signs of that change became apparent in 2008 and 2009. Protomo was a community-based, networked pre-incubator for those individuals and teams who were interested in entrepreneurship. The Protomo concept was financed by the Ministry of Economic Affairs and Employment, the Finnish Innovation Fund and several cities in which the Protomo concept was executed.

5.2 Acute crisis management

The year 2011 was a turning point in the transformation of the ICT sector of the Tampere region. Nokia's announcement of major shifts in its mobile phone platforms left large numbers of specialists unemployed but signals about change had existed even before that. There was a rising consciousness that the successful mobile phone path of Tampere was beginning to deteriorate and that a new path should be created. Universities, development organisations and other regional actors managed to respond quickly to the new situation. The reason for this is explained by Salkoaho and Ikonen (2015: 9): a loose co-operation network already existed and in the spring of 2011 it was assembled into a tight group of core actors: the city of Tampere, the council of Tampere region (statutory joint municipal authority), Tekes (the Finnish Funding Agency for Technology and Innovation [state]), Pirkanmaa ELY Centre (state), the innovation and product development expert Hermia Group (technology centre/innovation company), Tredea (RDA owned by municipalities), the Tampere Chamber of Commerce, TUT, UTA and Nokia Ltd.

These organisations started to meet in so-called 'Breakfast Meetings' on a regular basis. The group was unofficial in nature and consisted of a team of experts and influential figures from different organisations. The group's aim was to reflect on the possibilities of co-operation between public bodies and private enterprises amidst ongoing structural changes (Salkoaho 2015: 9). Research interviews confirmed that this group had a significant role in crisis management and coordination. The group was based on mutual trust and a common will to find solutions. There was even confidential information exchanged about redundancies so that employment officials were able to prepare for new waves of unemployment and to plan their next steps. This group had no official leader but was called together by Tredea. The lack of official leadership was not generally seen as a problem but as a natural state in a network where

all these organisations had their own roles. One concrete example of the co-operation between regional actors in the Tampere region has been the RecruIT Tampere recruitment event, which was started in 2011 and became a regular event. It has established its position as a meeting point for ICT-sector companies and professionals.

The ELY Centre played a responsible role as a regional state authority in charge of employment issues and supplying financial resources to manage unemployment. It led a project to prepare an action plan to minimise the damage caused by redundancies and carried out an extensive survey of ICT competence needed by business in the region. On the basis of this information, a large ICT retraining and qualifications upgrading umbrella programme, Spirit – ICT Future in the Tampere Region, was launched. Spirit supplied updating training courses and education with resources from, for example, the European Union European Social Fund and European Globalisation Fund. Spirit was the public complementary instrument to Nokia's own large Bridge programme. Approximately 2,000 people and 20 companies participated in Spirit retraining and upgrading of qualifications (Salkoaho and Ikonen 2015: 8).

Nokia showed previously unseen social responsibility with its global Bridge programme in the years 2011–2014 for its employees who were laid off or in danger of becoming redundant. There was also a more business-based reason behind the programme, however. Nokia's strategic motivation was 'not to make another Bochum', a phrase that referred to Nokia's Bochum factory shutdown in Germany, which caused huge negative publicity and damage to the company's reputation. The five different Nokia Bridge paths were (1) a new job inside Nokia, (2) a new job outside Nokia, (3) start-up entrepreneurship, (4) retraining, and (5) finding one's own personal path. The interest in entrepreneurship surprised everybody. Nokia provided 10,000–25,000 euro grants and technology licencing to those who wanted to start their own businesses. Bridge start-up evaluation, conducted by Aalto University (Kiuru, Handelberg and Rannikko 2013; Eskelinen 2015: 24-25), showed that the programme had good results. Approximately 100 new businesses were established by 550 people in Tampere. The range of companies diversified from ICT (40%) into multiple branches. After the Bridge project, Microsoft implemented a similar programme called Polku ('Path') when they began their redundancies. Polku has also had a positive reception.

Universities had an important role in the restructuration process. They provided supplementary education, conducted in co-operation with Nokia's Bridge and Spirit programmes. According to interviewees, a new kind of collaborative thinking also emerged in universities. TUT, UTA, and TAMK started to co-operate more closely because they needed to coordinate supplementary education to unite competences and create efficient training modules together. Another reason to co-operate was that they wanted to be more competitive against private-sector education providers in public tenders. TUT has also contributed to the success of new ICT companies in the region by being more active in reaching out to new research partners.

There was a shared concern about the crisis in the mobile phone industry in Tampere. All the regional players felt that they were in the same boat. For that reason, it is difficult to identify any actual conflicts between the regional partners in the attempts to solve the problem. Interviewees indicated that there was a consensus among organisations about the general strategic lines. Some different emphasis occurred on smaller issues, however. For example, the universities would have been interested in producing a broader and more general upgrading education. The employment authorities saw that there was a greater need for brief and highly specialised few-day courses on new technologies, however. Both models were carried out but the emphasis was placed on specialised quick courses.

Universities, especially TUT, needed to find new research partners to fill the gap that Nokia had left. The competition for funding also became more intense. New companions were found but starting a collaboration is never simple. It takes time to adapt to new organisational cultures. In some cases, a lot of work was carried out to establish a relationship and it was disappointing when it did not work out or the company simply left the Tampere region before the relationship was even created. Nevertheless, a new university–business network has formed in recent years.

The city of Tampere and regional development agency Tredea worked in the field of industrial development policy. Their task was to help generate new business by the Invest in Tampere programme, by supporting start-ups and by providing growth services. An important strategy was to promote Tampere as an attractive site for global and national companies, especially for the ICT sector. A key argument was that there was not only a substantial amount of qualified labour available but also high-quality physical infrastructure and research institutions. At the time of large redundancies, entire development teams became available. Tredea was marketing the added value of hiring teams. Intel was one of the rare newcomers to arrived in Tampere on time and managed to recruit MeeGo teams before they were scattered. There have been other global corporations that established a business site in Tampere but not all of them stayed permanently (Ericsson and Broadcom). One interpretation made by an interviewee was that they only wanted to utilise labour resources and did not truly integrate into the regional ecosystem.

Public actors cannot revitalise a regional business ecosystem by themselves. Enterprises have the key role in renewal. This renewal appeared as new companies were established from the ashes of Nokia and Microsoft. These next-generation ICT companies are pursuing new kinds of strategy that rely on a lack of hierarchical structures, openness and transparency, continuous learning, crowdsourcing, and ethical and meaningful assignments (Kärki 2015: 16). This opens up possibilities for networking in new ways. The new ICT businesses are also more versatile than before (e.g. games industry, cloud solutions, cyber safety, health technology and digitalisation of traditional industry).

Nokia did not disappear from the business ecosystem either. It fell out of the list of the ten most value-adding companies of Finland but it has made an impressive comeback as a network

company, rising to the first position in 2015. Still, the significance of Nokia as a whole has decreased. It does not hold the first position of most value-adding companies when indirect effects are taken into account because Nokia no longer has such a dominant role in the value chain (Ali-Yrkkö, Seppälä and Mattila 2016: 3-4). As an interesting detail, Nokia has quite recently re-entered the mobile phone business by following an entirely new business approach: It is not designing or manufacturing mobile phones, but has licensed the Nokia brand for phones and tablets to HMD Global Ltd. From the point of view of Nokia, this is a low-risk but, at best, very profitable strategy.

5.3 Path renewal by diversification

The concept of **path branching** can be used to describe and give a theoretical framework to efforts conducted in Tampere during the restructuration process. Path branching is a situation in which existing local firms and industries shift to different but related sectors (Boschma and Frenken 2011). Regions usually branch into industries that are technologically related to the pre-existing industries in the regions (Neffke et al. 2011: 237). In Tampere, the mobile phone industry diversified into other ICT sectors and merged with traditional industries as smart technologies. Lester (2007: 17-18) has introduced a typology of industrial transformation processes in which he identifies four different means of transformation: (1) indigenous creation (new technologies), (2) transplantation from elsewhere (of ideas new to the region, (3) diversification into technologically related industries and (4) upgrading of existing industries. It is easy to see that Tampere adopted the latter two means.

Path branching is often seen as industry driven (Neffke et al. 2011: 237). Drawing upon Garud et al. (2010), we want to emphasise the power of reflexive agency and the cumulative processes of gradual change as forces in path creation (or, in this case, path renewal), and thus also in resilience. By linking the concept of resilience to the conceptual framework provided by path dependency, we might be able to add analytical leverage to the efforts to understand how regions might escape their past and open up new paths. As Garud and Karnøe (2001) highlight, the initial conditions are not given, as assumed in path dependency studies, but are constructed by actors. Therefore, various incidents shaping paths ought not to be approached as exogenous and as manifesting something unpredictable, non-purposive and random but as emergent and serving as embedded contexts for agency. Garud and Karnøe's framework stresses the role of entrepreneurs although, as Djelic and Quack (2007) maintain, path development is also political by nature, and new paths may emerge as a result of the entrepreneurial efforts of science and policy actors despite the lack of business entrepreneurs (Sotarauta and Mustikkamäki 2015; Sotarauta and Suvinen, 2018). The many self-reinforcing mechanisms framing regional resilience are thus strategically manipulated and not only given from the outside, as we can see in the case of Tampere.

Universities have been an important resource in crisis management but perhaps they have an even greater role as long-term competence builders. Universities' role in building human

capital for the region in general cannot be underestimated. For example, Crescenzi, Luca and Milio (2015) have stated that human capital, especially tertiary educational attainment, is a strong predictor of regional growth, innovation and resilience. The resilience-building role of a university education has also become apparent in Tampere; the employment rates of highly educated ICT individuals have been considerably lower than those with only a secondary-level education (Neittaanmäki and Kinnunen 2016: 21).

Over the course of managing the crisis, regional actors have strengthened their collaboration in Tampere. Informal core group meetings to coordinate the restructuration process were an indication of a new kind of working approach that reflected the ideas of collaboration and openness. This shift in attitudes played an important role in constructing regional resilience. As Bristow and Healy (2014: 97-98) point out, the networked and polycentric nature of governance and policy is critical in resilience. Interviewed people who had participated in the restructuring processes identified some changes in local development thinking. Development policy practiced in the Tampere region has shifted from cluster and sector development towards increasingly cross-sectional thinking. There has been an effort to find themes that are common to all industries, such as 'smartness', which refers to the digitalisation of all kinds of processes and products. In addition, some other fields of local development policy, such as the talent-attraction policy, have been reshaped to increase human diversity and global linkages.

5.4 Building the future

'Smartness' also concerns the city itself. The city of Tampere has launched a new Smart Tampere programme (2017–2021), the key idea of which is to open big, digitalisation-related challenges of the city to be solved using innovative solutions by different stakeholders, such as companies, universities and citizens. The first seven themes of Smart Tampere are Smart Health, Smart Education, Smart Industry, Smart Building, Smart Infrastructure, Smart Mobility and Smart Government and Citizen. Through this programme, the city-organisation tries to find new ways to interact with different parties; it is not only about networking parties or conducting innovative public procurement, however, but placing the city as a living testing ground for many kinds of experimentation. This calls for many new kinds of role for the city-organisation (see Figure 3). Despite many problems (e.g. the high unemployment rate), the Tampere city-region is very attractive and hence a rapidly growing region. Consequently, there will be both private and public investments worth more than six billion euros in the next 10 years. The Smart Tampere programme aims at shaping those investments to serve the development of the smart city. This kind of development approach also gives new positions to different actors. Universities, for example, cannot work only for themselves if they want to participate in the programme; their activities should be related to the big, local challenges.

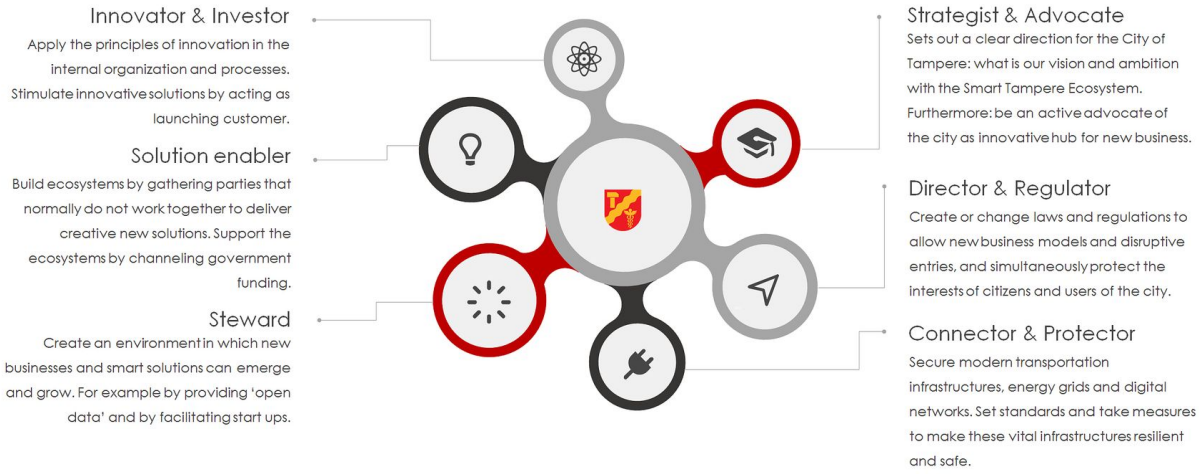


FIGURE 3. Roles of the city in the 'smart city ecosystem'
(Source: http://growsmarttogether.fi/about/city-of-tampere-ecosystem-role).

Since long before the programme-based development led by the city-organisation, there has also been a strong emphasis on fostering start-ups and seeking out novelty. The development of different kinds of open-innovation platforms has been one of the core instruments in carrying out this new policy. Currently, there is a plethora of different kinds of platform (e.g. Uusi Tehdas/New Factory, HealthHub, ITS-Factory, Smacc and Y-Kampus). The whole concept of an 'open-innovation platform' is somewhat fuzzy despite many attempts to define it. Raunio et al. (2016: 5) emphasise three key points. First, on platforms, activities focus not on the research teams of large companies and universities but on small companies and individuals, such as citizens or students. Second, platform orientation is realised through the engagement of digitalisation, open innovation and user orientation in the development of city services and business life. Third, in platform-based activities, the focus is on quick experiments and agile piloting, instead of multi-year development projects led by large companies and implemented by research institutions and a few corporate partners.

However, in Tampere, the universities seem to be involved in the activities of these new open-innovation platforms. That is only natural, because their competences and skilled people are still needed, even if the way to conduct the development and innovation processes has changed. Furthermore, the universities themselves have initiated a common process aimed at establishing a new higher education institute ('Tampere3') by combining the existing ones and creating new, modern procedures for research, education and societal engagement. This project has been seen as one of the key issues when considering the future of Tampere. The new higher education institute needs to be more attractive and progressive than the existing ones and it should work as 'a smart university in a smart city'. In sum, the majority of the recent local policy programmes and actions seem to contribute to the (constructed) regional resilience

by diversifying the local industrial base, encouraging entrepreneurship and (re)building knowledge competences.

6 Discussion: Towards constructed resilience?

This article presents the case of the evolution of the Nokia-led ICT industry in Tampere. The focus has especially been on the role of the universities, other public-sector organisations and development policy actions in this respect. The theoretical point of departure has been a two-fold one. First, we used the concepts of path creation, path extension, path exhaustion and path branching in order to point out the most meaningful phases in the history of the local industry. Second, we commented on those phases from the perspective of resilience.

In Tampere, the resilience capacity seemed to be rather high in the 1990s, when the ICT path was created and the system was in a flexible and creative state. By the end of the 1990s, Nokia and mobile phones had achieved tremendous growth and had established their role as an engine of economic development in the Tampere region. Tampere entered a stage of seemingly successful path extension in the first years of the 21st century. Simultaneously, however, the resilience of the local economic system had started to deteriorate, with its growing dependence on one actor. The first signs of trouble and path exhaustion in the mobile phone industry started to emerge around 2008. The real crisis and mass redundancies took place in 2011 and mobile phone development in Tampere ended in 2016.

There was a growing emphasis on constructing resilience from the first signs of path exhaustion but the most active measures of adjustment were introduced in 2011 and after. Path extinction in Tampere can be described as creative destruction. A new, versatile ICT business started to emerge from the ashes of Nokia and Microsoft. The diversification of ICT-related industries has increased regional resilience and Tampere has entered a phase of path branching. The relationship between path phase and resilience can be understood in the context of adaptive cycle models (e.g. Gunderson and Holling 2002; Davoudi 2012: 303). In adaptive cycles, the phases of growth, conservation, creative destruction and reorganisation vary cyclically. This has a clear resemblance to path stages. Davoudi (2012: 303) has shown how resilience varies in different phases of the cycle: resilience is greatest after creative destruction (in path creation/branching) and lowest at the conservation phase (in path extension). An interesting result of our research is that these cycles can be surprisingly fast in new, knowledge-based industrial regions.

Resilience is a character of a certain region or industry. We argue that it is not entirely an inherent feature and that different regional actors and policies can contribute to it significantly. The institutional settings, governance structures and policy actions have an effect on regions' capacity to resist and respond to change. In other words, resilience can be constructed. This view has been neglected to some extent, which is somewhat curious because there is a huge body of literature on competitiveness policies and the 'construction of competitiveness'.

Still, in the current economic environment, the characteristic of resilience seems increasingly relevant. The ability of a region to adapt to change, be it positive or negative, on its own basis is of great importance (e.g. Bristow 2010; Wolfe 2010; Bristow and Healy 2014: 100).

The rapid restructuration of the ICT industry in Tampere has been a major learning experience on two different levels or time-scales (cf. Bristow and Healy 2014: 100). First, managing the acute crises caused by massive lay-offs or divestments has taught the key policy-makers what to do and how to do it. Nokia and Microsoft have been unique cases in this respect, because their social responsibility has been quite high, due to many factors. Still, the role of public policy actions cannot be deprecated. The key lesson in this respect is the open, collaborative, trust-based and informal – but still decisive – way to act. This way of acting would presumably be beneficial in local economic development work in general. The challenge is to maintain that kind of spirit when the acute crisis is over. Second, the restructuration of the ICT industry has been a great lesson for anticipatory, long-term policies. The ICT industry in Tampere did very well for a long time and was highly competitive. Still, as history has demonstrated, it is easier than ever to lose a competitive edge in the global economy. Consequently, it is a notable economic risk for a city-region to rely on highly specialised industries that are too dependent on only a few large companies. The branching part of the Tampere story emphasises the diversification of the business structure (e.g. start-ups), openness to innovation (e.g. innovation platforms), a more thematic approach (e.g. 'smartness', smart city) and the active search for new development paths. This is not to say that the development work would have previously been of low quality or illogical. It made perfect sense in those conditions, but now the requirements are different.

Universities have had a significant role in the different development phases of the ICT industry in Tampere. To begin with, we argue, the whole cluster would not have emerged without the initial efforts by both scientific universities. That is also the case concerning the rapid growth and the 'glory days' of Nokia and its mobile phone business. At that time, both educational and research activities were of great importance. However, quite intense university–industry interaction, between Nokia and TUT in particular, was unable to prevent the dramatic restructuration of the local industry. One could even argue that the relationships were too tight, or at least that mental models were too homogenous.

Later, the universities were involved in the management of the acute crisis, but their role cannot be regarded as crucial. Currently, in the phase of path branching, the universities need to reorient themselves to the new setting. For example, the 'open-innovation platform approach' places universities in a quite different position to that of the more traditional methods of university–industry interaction. Still, on the more general level, the role of universities seems to be more important than ever. Universities are actors of local talent attraction and development. The current, more open innovation paradigm and start-up scene call for young, bright people who are willing to explore, experiment, fail and meet with success like no previous generation.

References

Ali-Yrkkö, J., Seppälä, T. and Mattila, J. (2016) *Suurten yritysten ja niiden arvoketjujenrooli taloudessa. ETLA raportit No 53.* [The Role of the Largest Companies and Their Value Chains in the Economy. ETLA reports No. 53]. Helsinki: ETLA – Research Institute of the Finnish Economy.

Ali-Yrkkö, J. (ed.) (2010) *Nokia and Finland in a Sea of Change. Series B 244.* Helsinki: ETLA – Research Institute of the Finnish Economy.

Arthur, W. B. (1989) 'Competing technologies, increasing returns, and "lock-in" by historical Events', *Economic Journal*, 99, 116–131.

Autere, J. (2000) 'Ohjelmistotuoteyritysten kasvuhakuisuus Helsingin, Oulun ja Tampereen seuduilla'. In J. Kostiainen and M. Sotarauta (eds.), *Kaupungit innovatiivisina toimintaympäristöinä*. Helsinki: Tekniikan akateemisten liitto TEK ry.

Boschma, R. and Frenken, K. (2011) 'Technological relatedness, related variety and economic geography'. In P. Cooke, B. Asheim, R. Boschma, R. Martin, D. Schwartz, and F. Tödtling (eds.), *Handbook of Regional Innovation and Growth*, 187–197. Cheltenham: Edward Elgar.

Boschma, R. and Sotarauta, M. (2007) 'Economic policy from an evolutionary perspective: The case of Finland', *International Journal of Entrepreneurship and Innovation Management,* 7:2–5, 156–173.

Bristow, G. (2010) 'Resilient regions: Re-"place"ing regional competitiveness', *Cambridge Journal of Regions, Economy and Society*, 3:1, 153–167.

Bristow, G. and Healy, A. (2014) 'Building resilient regions: Complex adaptive systems and the role of policy intervention', *Raumforschung und Raumordnung,* 72:2, 93–102.

Crescenzi, R., Luca, D. and Milio, S. (2015) 'The geography of the economic crisis in Europe: National macroeconomic conditions, regional structural factors and short-term economic performance', *Cambridge Journal of Regions, Economy and Society,* 9:1, 13–32.

Davoudi, S. (2012) 'Resilience: A bridging concept or a dead end?', *Planning Theory & Practice*, 13:2, 299–333.

Djelic, M-L. and Quack, S. (2007) 'Overcoming path dependency: Path generation in open systems', *Theory and Society,* 36:2, 161–186.

Eskelinen, P. (2015) 'Bridge – ohjelma yhteiskuntavastuunotosta' [Brigde – A Social Responsibility Programme]. In Salkoaho, U. and A. Knuuttila (eds.), *Uuden edessä. Start. Up. Tuki, toimet ja tulevaisuus ICT-alan rakennemuutoksessa* [In front of something new: Start-up support activities and the future of ICT-sector restructuring], 24–25. Tampere, Finland: The Centre for Economic Development, Transport and the Environment of Pirkanmaa.

Garud, R. and Karnøe, P. (2001) 'Path creation as a process of mindful deviation'. In Garud, R. and P. Karnøe (eds.), *Path Dependence and Creation*, 1–38. Mahwah, NJ: Lawrence Erlbaum.

Garud, R., Kumaraswamy, A. and Karnøe, P. (2010) 'Path dependence or path creation?', Journal *of Management Studies*, 47:4, 760–74.

Gunderson, L. H. and Holling, C. S. (2002) *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington, DC: Island Press.

Haapala, P. (2005) 'History of Tampere: The very long road to Informational City'. In A. Kasvio and A.-V. Anttiroiko (eds.), *e-City: Analysing Efforts to Generate Local Dynamism in the City of Tampere*, 163–182. Tampere: Tampere University Press.

Hassink, R. (2010a) 'Regional resilience: A promising concept to explain differences in regional economic adaptability?', *Cambridge Journal of Regions, Economy and Society*, 3:1, 45–58.

Hassink, R. (2010b) 'Locked in decline? On the role of regional lock-ins in old industrial areas'. In R. Boschma and R. Martin (eds.), *The Handbook of Evolutionary Economic Geography*, 450–468. London: Edward Elgar.

Henning, M., Stam, E. and Wenting, R. (2013) 'Path dependence research in regional economic development: Cacophony or knowledge accumulation?', *Regional Studies*, 47:8, 1348–1362.

Häikiö, M. (2002) *Globalisaatio: Telekommunikaation maailmanvalloitus 1992–2000*. Helsinki: Edita.

Isaksen, A. (2015) 'Industrial development in thin regions: Trapped in path extension?', *Journal of Economic Geography,* 15:3, 585–600.

Kiuru, P., Handelberg, J. and Rannikko, H. (2013) *Bridge It Up - työntekijöille tarjottujen startup -palveluiden vaikuttavuus – Case Nokian Bridge-ohjelma* [Bridge it up – the effectiveness of start-up services for employees – the Nokia Bridge Programme case]. Helsinki: Aalto University.

Kolehmainen, J. (2003) ´Territorial Agglomeration as a Local Innovation Environment: The Case of a Digital Media Agglomeration in Tampere, Finland. MIT IPC Local Innovation Systems Working Paper 03-002. Available at URL address http://ipc-lis.mit.edu/LIS03-002.pdf. Read 28th February 2017.

Kostiainen, J. & Sotarauta, M. 2003. Great Leap or Long March to Knowledge Economy: Institutions, Actors and Resources in the Development of Tampere, Finland. *European Planning Studies*. Vol:5, 415-438.

Kärki, T. (2015) 'Vähemmän ylhäältä johtamista, enemmän innokkuuden ja luovuuden ohjaamista ja tekemisen mahdollistamista' [Less top-to-bottom management, more possibilising of enthusiasm, creativity and doing]. In Salkoaho, U. and A. Knuuttila (eds.), *Uuden edessä. Start. Up. Tuki, toimet ja tulevaisuus ICT-alan rakennemuutoksessa*. [In front of something new: Start-up support activities and the future of ICT-sector restructuring], 14–15. Tampere, Finland: The Centre for Economic Development, Transport and the Environment of Pirkanmaa.

Laamanen, T., Lamberg, J.-A. and Vaara, E. (2016) 'Explanations of success and failure in management learning: What can we learn from Nokia's rise and fall?', *Academy of Management Learning & Education*, 15:1, 2–25.

Lehtimäki, M. (2005) *Strategy Configuration of a Technology Center as an Innovation System: Historical Perspective on the Story of Hermia*. Tampereen teknillinen yliopisto, Julkaisu 578. Tampere.

Lester, R. K. (2007) 'Universities, innovation, and the competitiveness of local economies: An overview'. In R. K. Lester and M. Sotarauta (eds.), *Innovation, Universities, and the Competitiveness of Regions*, 9–30*.* Helsinki: Tekes.

Martin, R. (2012) 'Regional economic resilience, hysteresis and recessionary shocks', *Journal of Economic Geography,* 12:1, 1–32.

Martin, R. and Sunley, P. (2006) 'Path dependence and regional economic evolution', *Journal of Economic Geography,* 6:4, 395–437.

Neffke, F., Henning, M. and Boschma, R. (2011) 'How do regions diversify over time? Industry relatedness and the development of new growth paths in regions', *Economic Geography*, 87:3 237–265.

Neittaanmäki, P. and Kinnunen, P. (2016) *Työttömyys IT-alalla koko Suomessa ja maakunnissa 2006–2015.* Informaatioteknologian tiedekunnan julkaisuja-sarja [Unemployment in the ICT sector in Finland and its regions: Publications of the Faculty of Information Science]. Jyväskylä: University of Jyväskylä

Raunio, M., Nordling, N., Ketola, T., Saarinen, J. P. and Heinikangas, A. (2016). *Open Innovation Platforms: An Approach to City Development.* Tampere: 6Aika.

Salkoaho, U. and Ikonen, J. (2015) 'Pelastuslauttojen rakentamiseen' [Building life rafts]. In Salkoaho, U. and A. Knuuttila (eds.), *Uuden edessä. Start. Up. Tuki, toimet ja tulevaisuus ICT-alan rakennemuutoksessa*. [In front of something new: Start-up support activities and the future of ICT-sector restructuring], 8–9. Tampere, Finland: The Centre for Economic Development, Transport and the Environment of Pirkanmaa.

Salkoaho, U. and Knuuttila, A. (eds.) (2015) *Uuden edessä. Start. Up. Tuki, toimet ja tulevaisuus ICT-alan rakennemuutoksessa*. [In front of something new: Start-up support activities and the future of ICT-sector restructuring]. Tampere, Finland: The Centre for Economic Development, Transport and the Environment of Pirkanmaa.

Sotarauta, M. and Mustikkamäki, N. (2015). 'Institutional entrepreneurship, power, and knowledge in innovation systems: Institutionalization of regenerative medicine in Tampere, Finland', *Environment and Planning C: Government and Policy,* 33:2, 342–357.

Sotarauta, M. and Suvinen, N. (2018) Institutional Agency and Path Creation: Institutional Path from Industrial to Knowledge City. In Isaksen, Arne, Roman Martin, and Michaela Trippl, eds. 2018. *New Avenues for Regional Innovation Systems - Theoretical Advances, Empirical Cases and Policy Lessons*. New York: Springer

Tödtling, F. and Trippl, M. (2013) 'Transformation of regional innovation systems: From old legacies to new development paths'. In P. Cooke (ed.), *Reframing Regional Development,* 297–317. London: Routledge.

Wolfe, D. A. (2010) 'The strategic management of core cities: Path dependence and economic adjustment in resilient regions', *Cambridge J Regions Econ Soc*, 3:1, 139–152.

Statistics and other material

Aamulehti news archives. *Suomen Media-arkisto,* <http://www.media-arkisto.com/>, 4/2/2017.

City of Tampere (2011) *Akseli. Tilastollisia tiedonantoja Tampereelta 1/2011* [Akseli: Statistical review of Tampere 1/2011], <http://www.pilkahdus.fi/sites/default/files/134_akseli_1_2011.pdf>, 28/2/2017.

City of Tampere (2016) *Tampereen työttömyysaste kuuden suurimman kaupungin korkein* [Unemployment rate in Tampere highest among Finland's six largest cities], Tiedotteet [Releases], 2/8/2016, <http://www.tampere.fi/tampereen-kaupunki/ajankohtaista/tiedotteet/2016/02/08022016_4.html>, 28/2/2017.

Ministry of Employment and Economy (2016) Avoimet työpaikat kuukauden aikana ammatin ja toimialan mukaan ELY-keskuksittain/maakunnittain [Vacancies per month by sector and region], Sector Online database, <http://www.temtoimialapalvelu.fi/en/mee_business_sector_services/sector_online>, 1/2/2017.

Statistics Finland (2016) Alueellinen yritystoimintatilasto [Regional statistics on enterprises], StaFin database,

<http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__yri__alyr/?tablelist=true&rxid=0a7dc93a-e71f-4e02-ad79-b82cd63e104d>, 1/2/2017.

Tampere Chamber of Commerce (2012) *Kyselyt ja selvitykset 2011–2012* [Surveys and reviews 2011–2012], <http://tampere-chamber-fi-bin.directo.fi/@Bin/a111dcebf0370b46f9752b48667a9265/1488269590/application/pdf/2512661/Kyselyt_ja_selvitykset_2011-2012.pdf>, 28/2/2017.>, 1/2/2017.

Tampere Chamber of Commerce (2016) *Kyselyt ja selvitykset 2015–2016. Surveys and reviews 2015–2016,* <http://tampere-chamber-fi-bin.directo.fi/@Bin/14c966576432a78b4035d4af342d67d7/1488272265/application/pdf/4605773/Kyselytjaselvitykset2015%202016.pdf> 3/2/2017.