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Innovation ecosystems in small countries – The case of Luxembourg

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Abstract

Since it emerged at the start of the decade, the ecosystem model of Martin Fransman (Fransman, 2010) has been widely applied to understand innovative processes within the information and communication technology (ICT) sector – see, for example, Binsfeld, Whalley, & Pugalis (2017b). The framework has recently been updated (Fransman, 2018) so that an innovation ecosystem is defined as "of a group of interdependent players and processes who together through their interactions, make innovation happen". He has also proposed a deeper examination of the dynamics of how innovation happens within innovation systems, and who is in charge of making innovation happen.

This paper seeks to apply this evolved understanding of innovative processes to Luxembourg. More specifically, the paper will describe and comment about the evolution of the ICT ecosystem in recent years. The paper will also present and reflect on a series of recent government initiatives that have been launched with the intention of stimulating the development of the ecosystem. Through such an approach, we will demonstrate the pivotal role played by the government as the main driver behind innovation in the ecosystem. The paper also outlines Luxembourg's national skills strategy and explores the degree to which these various initiatives may be integrated together.

1. Introduction

Information and communication technologies (ICT) are a crucial sector of the Luxembourgish economy. According to Eurostat, in 2013, the sector contributed approximately 7% of GVA (Service des Médias et des Communications, 2013). In international terms, particularly compared with other European countries, this is very high. The sector includes about 2000 companies, employing circa 5% of the active working population (European Commission, 2016). In part this is due to a number of internationally renowned actors (such as, for example, Amazon, eBay, iTunes, KABAM, Microsoft, PayPal, Rakuten, RealNetworks, Skype and Vodafone) that have chosen Luxembourg as their base to access the European market and, in part, due to the high demand of ICT services in Luxembourg's well developed financial industry (Luxembourg for Business, 2013a).

Luxembourg's ICT sector is also one of the most innovative sectors in the country, with over 20% of companies being classified as "persistent innovators" (Statec, 2014). According to the Global Information Technology Report, Luxembourg offers an "ideal environment to support new technology innovations" (World Economic Forum, 2015). In 2015 the country ranked ninth worldwide when it came to leveraging ICTs for social and economic impact¹, and the importance of the ICT sector for the Luxembourg government is also highlighted by its ranking as fourth and fifth, respectively in terms of government success in ICT promotion and the importance of ICT to the government's vision (Luxembourg for Finance, 2015).

For several years, the government has been promoting Luxembourg as a key location for ICT with the aim of attracting new activities, establishing new businesses and encouraging private investment (Luxembourg for Business, 2013b). As part of this, initiatives have been launched to develop ICT research and development, with a focus on security, reliability and the trustworthiness of ICT systems and services (Funck, 2013).

In order to provide policy-makers with a comprehensive analytical foundation, scholars often propose to examine the ICT sector as an business ecosystem, which consists of a number of interconnected organisations and actors (Kim, Lee, & Han, 2010). Since it emerged at the start of the decade, the ecosystem model of Martin Fransman (Fransman, 2010) has been widely applied to understand innovative processes within the information and communication technology (ICT) sector – see, for example, Binsfeld, Whalley, & Pugalis, 2017b. Fransman (2010 p. xxi) suggests that "every country has an ICT ecosystem, although the players, their symbiotic interactions and the institutions in which they are embedded are different. The task of national policy-makers and regulators in all countries is to understand how their ICT ecosystem works, its strengths and weaknesses, and what might be done to improve its contribution". Thus, it is the purpose of this paper to shine an investigative light on Luxembourg's ICT ecosystem, building on and updating our previous analysis.

This paper seeks to apply Fransman's evolved understanding to Luxembourg. More specifically, the paper will describe and then explain the structure and main characteristics of Luxembourg's ICT ecosystem. Particular attention will be paid towards its economic characteristics, and analysis of the roles and interrelationships that exist between different actors and organisations. The evolution of the ICT ecosystem between 2015 and 2018 will be demonstrated and government initiatives to foster the development of the ecosystem will be presented. In addition, the country's recent national digital skills strategy will be discussed.

It is hoped that this study, just as the authors' previous work (Binsfeld, Pugalis, & Whalley, 2015; Binsfeld, Whalley, & Pugalis, 2014, 2016c, 2017), will lead to a better understanding of the innovative

¹ in the Networked Readiness Index (World Economic Forum)

forces that shape the ecosystem. As one of the few analyses of ICT ecosystems in small countries, this study is important and unique. Moreover, it is intended to be of use and interest to policy-makers, managers, and decision makers or actors within the different layers of the ICT ecosystem in Luxembourg and beyond.

The remainder of this paper is structured as follows. Section 2 briefly presents those models used to analyse and evaluate the ICT sector and argues the case for the application of the layered model proposed by Fransman. Attention then shifts to the main outcomes of the study. In section 3, the main actors are identified and their activities within the different layers detailed highlighted. Section 4 presents the evolution of Luxembourg's ICT ecosystem during recent years. It also extends the boundaries of this ecosystem to include e-commerce and media activities. Section 5 identifies recent government activities which aimed to stimulate the development of the ecosystem. Section 6 highlights the importance of the underlying sklls and competences for the success of the different initiatives and presents the national digital skills strategy of Luxembourg. Finally, section 7 provides conclusions and shows avenues for further research.

2. Innovation Ecosystems

It is important to examine "innovation ecosystems" in order to understand the co-evolution between technological and economic as well as regulatory forces and developments to provide a comprehensive basis for policy makers to act. For the purpose of understanding the structure of the ICT ecosystem in Luxembourg, we propose here to use the layer model described by Fransman (Fransman, 2001, 2002a, 2002b, 2004, 2006, 2014).

When looking at the supply side of the ICT ecosystem, four types of actors can be identified:

Layer I: Network element providers (e.g. Cisco, Samsung, Alcatel-Lucent, Ericsson, Nokia Networks)

Layer II: Network operators (fixed and mobile) (e.g. BT, Deutsche Telekom, Vodafone)

Layer III: Content & application providers (e.g. Google, Apple, YouTube)

Layer IV: Final consumers and users of ICT services





Fransman (Fransman, 2007) suggested this model building on experiences of telecommunications and ICT engineers who had, over several years, used the layered models for organising their work and knowledge interdependencies. Such a model allows for a clear definition of the industry or ecosystem boundaries and subsectors, a modularisation and hierarchy of the different categories of actors within the system as well as the 'interfaces' and relationships between actors. It also facilitates describing the industrial organisation of the ICT ecosystem, and the identification of the location of R&D. It also enables entry and exit barriers to be identified, and importantly, light shed on the role of customer(s). It thus provides a simple yet effective way to gain an understanding of the different types of actors, their respective roles, the importance to the sector as well as the interrelations that occur between them.

On the other hand, it is essentially a static model, which fails to reflect the dynamics of change. Moreover, it is not well suited to identify modes of cooperation and coordination between the different actors, nor does it cope with diversity within the different layers. Finally, it does not take into account externalities such as interacting institutions or organisations such as, for example, ICT regulators or financial institutions.

Acknowledging these developments, Fransman (2007, 2010, 2011), has focused on the role of the dynamic, or, as Fransman calls them, 'symbiotic' relationships that exist between the different layers and their role in innovation (Fransman, 2014). This is shown in Figure 2. These relationships can be described as multi-dimensional, representing financial and material flows as well as information and input flows into the innovation processes that occur within the ecosystem.

In the 'new ICT ecosystem' (i.e., post-internet), users are gaining a presence on the supply side of the system by co-creating with suppliers. In contrast to the so-called 'old ICT ecosystem' (i.e., pre-internet), which could be described as a closed innovation system with the most important links being between network operators and network suppliers (Layers I and II), the new ICT ecosystem is more open, more dynamic and more complex. In recent years, the focus has shifted to the interaction between platform, content and application providers (Layer III) and the ecosystem has become more dynamic, with the relationships between the different actors and the environment also becoming more complicated.





An example of how this model can be used to understand the interactions between different actors is provided by, among others, Arlandis & Ciriani (2010). Their paper includes a detailed database of

players in the different layers but takes a high- level view by looking at different economic clusters such as the EU, the US and Asia and they have been able to the relative (compared to the EU) dominance of US and Asia's ICT ecosystems. Another application of the Fransman model can be found in Veugelers (2012). Here the model is also used to understand why Europe's ICT companies are lagging behind those in the US especially with regard to the "leading platform providers who are capturing most of the value in the ICT ecosystem". It is argued that a very fragmented EU market, lack of entrepreneurial mind-set, as well as lack of risk capital are the main stumbling points blocking the development of the ecosystem.

The framework has recently been updated (Fransman, 2018) so that an innovation ecosystem is defined as "a group of interdependent players and processes who together through their interactions, make innovation happen". Fransman has also proposed a deeper examination of the dynamics of how innovation happens within innovation systems, and who is in charge of making innovation happen. This resulted in a 'check list' of propositions regarding how innovation occurs. These are:

- 1. The innovation process begins with an innovation hypothesis
- 2. An innovator buyer user relationship is central
- 3. Innovation is about the imagined deemed feasible
- 4. The hypothesis is held with uncertainty, it embodies subjective expectations
- 5. The hypothesis must be tested
- 6. Tests provide information feedback to potentially adapt or reject the hypothesis
- 7. The innovation process inherently carries the possibility of ignorance, error and mistakes
- 8. Innovation is not ex-ante predictable
- 9. Providers of knowledge, finance and institutional rules significantly influence how innovation happens.

Fransman (2018) draws particular attention to the last proposition, arguing that it is essential. Due to this, and the significant role played by financial services in Luxembourg, subsequrent sections will pay attention to how the providers of knowledge as well as rules shape innovative processes within the country.

3. The recent evolution of the ICT Ecosystem in Luxembourg

ICT is a crucial sector in the Luxembourgish economy, both in its own right and as an enabler of other sectors with the financial sector being the most prominent of these. ICT is also a cross-cutting tool for the economy. It can be broadly split into 3 categories of stakeholders:

- ICT producers, which according to the strict OECD (2011) definition includes areas such as electronic hardware and components, telecommunications, ICT services or software, etc. This equates to layer 1 in Fransman's model.
- Activities involving digital content, the existence of which is linked to the emergence of ICT. Examples here include online services, video games and e-commerce. These activites correspond to Layers 2 and 3 of Fransman's model.
- ICT users who use ICT to make productivity gains but whose activities predate the emergence of ICT. As such, examples here are disparate for example, banks, insurance, automotive and aeronautics, distribution, administration and tourism with these activities occurring in Layer 4 of the model.

The analysis below draws on the following definitions.

• Strict definition: this definition includes the production of ICT hardware and software (manufacturing), the distribution of ICT products and services (commerce) and the provision of services to facilitate the use of ICT (service activities) on the basis of the OECD definitions of the ICT sector

• Broad definition: this definition is more difficult to pinpoint as it comprises other activities indirectly linked to ICT use, such as activities which are dependent upon the emergence of ICT, e.g. e-commerce, media and digital content.

3.1 ICT sector in the strict sense

Building on these definitions, Table 1 (below) shows the evolution of the ICT services sector in the strict sense from 2008 to 2018.

ICT (strict definition)	2005	2007	2009	2011	2012	2013	2014	2015	2016
Number of companies	1,357	1,497	1,618	1,755	1,838	1,960	2,054	2,203	2,266
	5.1%	5.3%	5.3%	5.4%	5.5%	5.6%	5.7%	6.0%	6.1%
Number of people employed	10,467	12,458	13,888	15,022	15,353	15,833	16,493	16,726	17,319
	3.4%	3.7%	3.9%	4.1%	4.0%	4.1%	4.2%	4.1%	4.1,%
Number of salaried workers	10,303	12,309	13,722	14,816	15,169	15,613	16,252	16,429	16,955
	3.5%	3.9%	4.1%	4.2%	4.2%	4.3%	4.3%	4.3%	4.3%
Value added at factor cost (in EUR million)	1,593.4	1,887.3	2,186.1	2,766.1	2,853.3	2,989.7	3,520.8	3,459.4	3,242.5
	6.0%	5.8%	6.7%	7.2%	7.3%	7.3%	8.0%	7.5%	6.8%
Turnover (in EUR million)	5,398.0	6,064.7	6,635.9	9,694.2	11,487.2*	14,652.6	17,226.8	16,767.0	14,313.1
Staff costs (in EUR million)	629.6	802.3	920.1	1,074.1	1,079.1	1,139.2	1,210.1	1,268.8	1,304.5
Gross investment in tangible goods (in EUR million)	125.7	340.8	454.6	649.3	628.7	336.1	928.5	611.2	346.5
Turnover per employee (in EUR million)	515.7	486.8	477.8	645.3	745.7	925.4	1,044.4	1,002.4	826.4
Apparent labour productivity (gross value added per employee) (in EUR million)	152.2	151.5	157.4	184.1	185.8	188.9	213.5	206.8	187.2
Investment rate (investment/value added at factor cost)	7.9%	18.1%	20.8%	23.5%	22.0%	11.2%	26.4%	17.7%	10.7%

Table 1 - Indicators relating to the ICT services sector

Source: Structural Business Statistics (STATEC)

Note: Apart from the 'number of companies' variable, which refers to the whole of the ICT industry (manufacturing and service providers), all other above indicators refer only to ICT services due to the confidential nature of data relating to ICT manufacturing activities (3 companies). The percentages shown in italics represent the sector's share of the total indicator for Luxembourg. * Break in the series due to the reclassification of certain companies.

Between 2005 and 2016, the number of businesses active in the ICT sector has increased considerably: in 2005 there were 1,357 listed ICT companies, a figure which had risen to 2,266 by 2016 (+67%, i.e., an average annual growth rate of +4.8%), with the strongest growth (+7.3%) occuring between 2015 and 2016. In 2016 these companies, which represented 6.1% of all the companies in Luxembourg, employed 17,319 staff, which corresponded to 4.1% of workers employed in the country.

Following a sharp rise in the number of jobs in ICT before the crisis (2005-2008), recruitment in the sector has continued to increase (see Figure 3). Between 2005 and 2016, the number of jobs has increased by 65.5%, with significant job growth (+3.5%) occuring between 2015 and 2016.



Figure 3: Evolution of the number of employees and companies in the ICT sector (strict definition). Source: Structural Business Statistics (STATEC)

By the end of 2016, the 2,266 ICT companies were creating 6.8% of the value added of the Luxembourg economy, i.e., over $\in 3.2$ billion. It is worth noting that while this is an an increase of 104% compared to 2005, the sum has been declining since 2014. 1.7% of this value added was generated by companies in the space technology sector, which fell under the Eurostat definition of ICT companies (see Figure 4). Telecommunications activities, some of which are also represented by the space technologies sector, created most of the value added for the whole ICT sector in 2016 (47.5%), which is more than in 2014 (46.8%). Programming, consultancy and other ICT activities and electronic games and other software production reached respectively 27.4% and 3.6% of the whole ICT sector (compared to 22.9% and 3.8% in 2014). In total, the ICT sector (strict definition) generated a gross value added of over $\in 3.2$ billion and a turnover of over $\in 14.3$ billion in 2016.



Figure 4: Breakdown of value added at factor cost in the ICT sector (strict definition) Source: Structural Business Statistics (STATEC), Balance sheets available at the RCS, Calculation: ODC

However, since 2014, there has been a drop in the turnover of the ICT sector. This phenomenon could be linked to a reduction in online purchases made by European consumers following the change to e-VAT regulations, or to the migration of part of the sector's large players' turnover to branches outside

the country, and the permanent departure abroad of some companies. Despite the drop in turnover of these companies (of approximately €2.9 billion compared to 2014) and the decrease of the value added generated, the ICT sector is arguably performing well if one takes into account the number of new companies and jobs created in the sector between 2014 and 2016. Indeed, in 2016, the sector represented 4.3% of the salaried jobs in the country (compared to 3.5% in 2005), i.e., around 17,000 salaried jobs.

Jobs in the ICT sector are mainly concentrated in the ICT services (89.6%) and trade (10.2%) sectors. ICT manufacturing in Luxembourg only provides 0.2% of the total number of paid jobs in the sector. However, while over half of the jobs in the sector were to be found in the domain of programming, consultancy and other ICT activities, with over 9,460 workers between them, these activities represented just 27.4% of the overall value added of the sector, i.e., nearly €890 million and a turnover of around €2.4 billion. The 115 companies active in the production of electronic games and other software (+47.4% compared to 2014) produced 3.6% of the value added of the sector, i.e., €118 million, a slight increase compared to 2015.



3.2 ICT Sector in the broader sense

Figure 5: Evolution of the content and media sector Source: Structural Business Statistics (STATEC)

CONTENT AND MEDIA

In addition to strict definition of the ICT sector, the authors also carried out an analysis of wider ICTrelated activities in order to gain a more comprehensive understanding of the sector and include activities whose existence is dependent upon ICT such as content and media services, activities that are sometimes also referred to as information services. At the end of 2016, this sector contained 331 companies employing 2,338 staff and represented a gross value added of the country's economy of 0.5%. RTL Group² is Luxembourg's major player in this sector - see Figure 5.

E-COMMERCE

In addition to the 'content and media' activities, distance-selling (e-commerce) should also be included as it is an activity, which needs 'traditional' ICT infrastructure to exist. Such activities, very significant in Luxembourg's ICT landscape, deserve special attention in order to present the as complete snapshot as possible of the ICT sector. The e-commerce sector has grown exponentially since its arrival in Luxembourg, a country, which for several years, has been very attractive for e-commerce companies in spite of the recent departure of some large companies in the sector, e.g., Netflix, Kabam and Zynga.

In order to measure the economic characteristics of this sector, the Ministry of the Economy worked with the Ministry of State's Media and Communications Service to develop a list of key players in the sector. The list was based on a definition of e-commerce that included several activities such as distance selling, online gaming and financing (predominantly mobile payment) which are dependent upon e-commerce and could not exist without it. Since then, indicators related to the economic performance of the companies on this list have been monitored and updated so as to take the sector's new important players into account.



Figure 6: Evolution of the content and media sector Source: Structural Business Statistics (STATEC)

Following changes to regulation concerning distant selling (e-VAT) in the EU, entering into force on the 1st of January 2015, several companies left Luxembourg and this has a direct impact on the turnover – it decline despite an increase in e-commerce activities more broadly being observed (Observatoire de la compétitivité, 2018). Thus, the effect of these regulatory changes has begun to be

² See <u>http://www.rtlgroup.com/en/rtlgroup.cfm</u> accessed 18.5.2019

felt on the economic performance of those companies that remained active in Luxembourg after the law changed.

The departure of large players has had an impact on the overall performance of the sector. The value added generated by this type of activity in 2016 continued to fall in absolute terms and represented under \notin 900 million, i.e., only 1.9% of the economy (see Figure 7). Based on data collected by the Trade and Company Register, Amazon remained the largest player in the sector in Luxembourg though it now generated only 1.1% of the total value added of the economy. This decrease, compared to the last two years, can arguably be attributed to regulatory changes beginning in 2016. It is also the case for other companies, who also witnessed the direct or indirect impact of these regulatory changes, following a possible drop in European consumers' online purchases or the migration of part of the turnover to other branches of the same groups abroad. Despite these developments, the number of employees in Luxembourg of Amazon increased from 880 in 2015 to 1,210 in 2016.

In order to appraise the ICT sector in its broader definition, it seems useful to add up the results of the different aspects to obtain a comprehensive overview of the sector. As a whole, the ICT sector employed 21,103 salaried workers (5.3% of the total salaried workforce) in 2,641 companies in Luxembourg (7.1% of companies) in 2016. Since 2005, the number of companies and the size of the salaried workforce increased by 59.1% and 65.4% respectively, with a respective annual growth rate of 4.3% and 4.7%.

The added value generated by the ICT sector as a whole is made of different sub-sectors. In 2016, the gross added value of ICT according to the Eurostat definition (including space technologies) was 6.8%. However, by also including related activities such as e-commerce and the content and media sector, which are dependent on ICT, the figure was close to 9.5% of Luxembourg's economy. 2016 was, therefore, a good year for the ICT sector in absolute terms, namely, overall there was an increase in the number of company and job creation despite a drop in turnover by some companies in the sector.



Figure 7: Added value generated by e-commerce as a share of the national economy

Note: Data available at the Trade and Companies Register and Balance Sheet Centre at the time of drafting this document. The calculation basis may be lower than the number of companies recorded for the same year. (p): provisional data Source: Balance sheets available at the RCS, Central Balance Sheet Data (STATEC), IGSS; Calculation: Observatoire de la compétitivité

The value added generated is also impacted by this phenomenon: value added has been falling since 2014, reaching 6.8% of the economy according to Eurostat's ICT definition. The same downward trend can also be seen in the ICT sector (broad definition). Indeed, in 2016, it represented 9.5% of the country's value added (Figure 8).



Figure 8: Evolution of the share of ICT (broad definition) added value as a % of the economy as a whole. Source: Observatoire de la compétivité 2018

4. Government initiatives to develop the sector

This section presents a snapshot of recent government initiatives designed to encourage the development of the ICT ecosystem in Luxembourg. Collectively, these initiatives show that the Government is the main driving force behind innovation within the ecosystem. This can be explained by the lack of, or very limited local presence of, ICT equipment (Layer 1) providers in Luxembourg. It is often these actors, as mentioned by Fransman (Fransman, 2014), which drive research and development and create innovations which will be subsequently used by actors in the other layers.

DIGITAL LUXEMBOURG

Digital Luxembourg³, founded in 2014, is a multidisciplinary government initiative working with public, private and academic players to harness digitalization for positive transformation of Luxembourg's economy. To achieve this goal, it approaches digitalization holistically, focusing on strengthening five key areas: skills, policy, infrastructure, ecosystem and government. Executing the

³ Further details see www. <u>https://digital-luxembourg.public.lu/</u> accessed 18.5.2019

Luxembourg government's digitalization strategy, Digital Luxembourg enables new projects and supports existing ones. It also helps promoting Luxembourg as a "digital nation" (Digital Luxembourg, 2018b) internationally.

MINISTRY OF DIGITALISATION

Following the general election in October 2018, the new Government decided to place digitalization at the center of its concerns by creating a Ministry of Digitalization, headed by the Prime Minister, Minister of Digitalization and a Deputy Minister for Digitalization (Gouvernment du Luxembourg, 2018).

The Prime Minister asserted in his statement to MPs: "If we have created a new ministry, it is not only to advance the overall technological development in the areas important to our economy and to develop new strategies for our country to move forward, but also to improve our daily life and the various administrative processes". A large part of the activities of the Ministry of Digitalization have as their main objective to facilitate the life of the country's population. According to official statements, the priorities of this new Ministry will be the following⁴:

- Implementation of the "Digital Lëtzebuerg" action plan and monitoring of the ICT sector (shared competence with the Minister of the Economy and the Minister of Communications and Media).
- Promotion of the ICT sector (shared competence with the Minister of the Economy).
- Digitalization of administrative procedures.
- Digital transformation of the Public Administration.
- Setting up a High Committee of Digital Transformation.
- Development and implementation of a plan regarding the Internet of Things.
- Digital Infrastructure Development (in consultation with the Minister of Communications and Media).
- Development of a national strategy in the field of artificial intelligence (AI) (in consultation with the Minister of Communications and Media and the Minister of the Economy).
- Implementation of the 5G national strategy and development of pilot projects (in consultation with the Minister of Communications and Media).
- Favouring Digital inclusion.
- Promotion and organization of the automation of the state administrations, especially regarding the collection, transmission and processing of data.
- Seeking synergies between the various state administrations and optimizing their information exchanges.
- Assisting the various state administrations in carrying out routine IT work and managing fixed and mobile communication systems.
- Electronic archiving with the state.
- Daily management of the Government Communication and IT infrastructure (in consultation with the Minister of State).

As many of these objectives involve coordinating with other government bodies, and seem to overlap, at least partially, with the activities of Digital Luxembourg, it remains to be seen how effective the new Ministry will be.

⁴ See <u>https://digital.gouvernement.lu/fr/le-ministere.html</u> accessed 18.5.2019

CYBERSECURITY

On 8th May 2018, Luxembourg presented its 3rd National Cybersecurity Strategy (Digital Luxembourg, 2018a). The objective of this strategy is to provide an environment conducive to digital development, while ensuring security for all stakeholders. In order to do this, the strategy revolves around three priorities: to strengthen public confidence in the digital environment, to protect digital infrastructures and to promote Luxembourg's economic position.

Cybercrime, cyber-attacks and security loopholes represent real threats and give rise to a lack of confidence. Hence, the strategy's emphasis on strengthening public confidence in the digital environment by informing them about the risks associated with the use of ICTs and by raising awareness among all parties concerned about information security. Multimedia information campaigns are integral to the strategy, just as is establishing a model of responsible disclosure – i.e., a stakeholder is entitled to a specific period in which it has to correct the vulnerability before the information is passed onto the public – and the fight against cybercrime.

The strategy also aims to make Luxembourg a leading player in cybersecurity. The government intends to develop a set of innovative projects with the purpose of launching new products and services within the field of cybersecurity. In addition, training and other (e.g., observatory and testing) services are offered by a Cybersecurity Competence Center $(C3)^5$. It is managed by an economic interest grouping⁶ that brings together expertise in the field in Luxembourg.

HIGH PERFORMANCE COMPUTING

High Performance Computing (HPC) most generally refers to the practice of aggregating computing power in a way that delivers much higher performance than one could get out of a typical desktop computer. High performance computing is often seen as the key to the digitisation of industry and the data economy (KPMG, 2013). Its many practical applications, it is hoped, will provide benefits to a wide range of industrial and business sectors, as well as to users from academia, scientific communities and the public sector.

Originating from an initiative by Luxembourg, the European Council launched, in June 2018, EuroHPC⁷, a joint European initiative. This is based on an agreement signed in March 2017 between Luxembourg, Italy, Spain, France, Germany, Portugal and the Netherlands. Since then, Belgium, Slovenia, Bulgaria, Switzerland, Greece and Croatia have also joined. EuroHPC will oversee the pooling of resources within Europe to develop supercomputers for processing big data, which is essential for addressing current major scientific and societal challenges. EuroHPC will be based in Luxembourg and will manage around €1 billion of public funds that will be invested in the initiative between 2018 and 2020 (Ministère de l'Economie, 2018).

EuroHPC will take the form of a public-private partnership. Members of the initiative will be the EU, individual EU countries, third-party countries associated with the Horizon 2020 programme and private associations.

While waiting for the implementation of the European HPC network, Luxembourg has also decided to acquire in 2019 its own supercomputer. This supercomputer, which will benefit from European co-funding of 35%, will later on be connected to the wider EuroHPC network (Lambotte, 2019).

⁵ See <u>https://www.c-3.lu/</u> accessed 18.5.2019

⁶ See <u>www.securitymadein.lu</u> accessed 18.5.2019

⁷ See <u>https://www.consilium.europa.eu/en/press/press-releases/2018/06/25/supercomputers-</u> <u>council-agrees-to-develop-high-tech-infrastructure/</u> accessed 18.5.2019

5G MOBILE NETWORKS

At the start of 2017, Digital Luxembourg's infrastructure group consulted with the key players in the Grand Duchy who are affected by 5G, including the regulator, mobile network operators, academics, technology companies and stakeholders in the field of machine-to-machine communication (M2M) and/or the Internet of Things (IoT). A 5G sub-group held its first meeting in July 2017 to exchange ideas on the various aspects of the future 5G ecosystem in Luxembourg, based on the bilateral consultations held earlier in the same year. The group also considered the roadmap needed to reach the objective, including what spectrum to use, business models required, the role of satellites, and the role played by 5G in autonomous networked vehicles. The consultation undertaken by the infrastructure group showed that operators do not expect to immediately widely deploy 5G, but instead intend to develop a series of trials with industry partners.

The Department for Media, Telecommunications and Digital Policy followed up on this first consultation by carrying out an in-depth study on the opportunities and challenges linked to introducing 5G in the Grand Duchy (Incites, 2018). The study was based on discussions with a wide range of national stakeholders in the Luxembourgish ecosystem. It looked at various aspects involved in introducing 5G, such as the business models that could be adopted and market demand. Moreover, the consultation identified five potential pioneer areas for the initial introduction of 5G in Luxembourg. This, in turn, lead to the creation of a national 5G strategy that was, in October 2018, presented to the general public (Digital Lëtzebuerg, 2018).

It remains to be seen whether 5G mobile networks will really be a revolution or evolution in mobile communications. In the meanwhile, however, with the support of the Government, several pilot projects (Digital Lëtzebuerg, 2018) have been launched which will facilitate the introduction of 5G for the different mobile network operators (Layer 2 actors) that currently exist.

FINTECH

Given the relative importance of the financial sector for Luxembourg's economy (EIU, 2008; Michaux, 2013), the Government has favoured, over the last couple of years, the development of Fintech activities (Cencetti, 2015; KPMG, 2014; Labro, 2015; Luxembourg for Finance, 2015; Thibaut, 2015). This has led to the creation of specific business development agency: the Luxembourg House of Financial Technologies⁸. The LHoFT Foundation is a public - private sector initiative that intends to drive technology innovation for Luxembourg's financial services industry, connecting the domestic and international Fintech community to develop appropriate solutions.

The LHoFT Foundation hosts Fintech firms in a co-working facility and support them in their growth. It also partners with larger corporates from the financial services and technology industries to help them meet their innovation goals, and facilitates their accessing the right people and resources in Luxembourg. Finally, they intend to enable venture capital firms / investors, government agencies, financial services / fintech associations, assisting them in order to fulfil their Fintech ambitions in Luxembourg. In the meanwhile, this initiative has been relatively successful, and a lively Fintech ecosystem has developed⁹.

GOOGLE TO IMPLEMENT A DATA CENTRE IN LUXEMBOURG

Initially based on a private sector initiative, the Minister of Economy announced in December 2017 that Google had acquired the necessary ground to build a large scale data centre as part of its development in Europe (IT Nation, 2017). This datacenter alone would be larger than all of the

⁸ See <u>https://www.lhoft.com/</u> accessed 18.5.2019

⁹ See <u>https://www.fintechmap.lu/</u> accessed 18.5.2019

currently existing datacenters in Luxembourg combined (Soluxions, 2013). As such, it represents a major development for the local ICT sector. The overall investment is deemed to be around €1 billion and dozens of new ICT related jobs could be created in the process. More recently, the Government announced that major planning permissions issues had been successfully addressed (Léonard, 2019). The onus is now on Google to confirm its plans and commence developing the infrastructure.

LUXEMBOURG SPACE RESOURCES

The Minister of Economy, in a effort to diversify the local economy, also announced in 2015 that Luxembourg would invest in space mining activities and would create a legal environment to secure this type of activities (Schneider, 2015). Whilst this is not wholly aligned with the ICT ecosystem, developing space exploration and mining activities will recently require a lot of ICT infrastructure and myriad softward applications. In the meanwhile, this activity has attracted a lot of international attention. Several international firms have relocated to Luxembourg¹⁰ and international agreements as well a national space agency¹¹ have been launched.

All of the aforementioned initiatives fulfill the propositions identified by Fransman and, therefore, qualify as innovation activities. It is, however, inherently uncertain whether these initiatives are likely to partially let alone fully succeed. This uncertainly might explain why most of the initiatives are in some form driven or at least supported by the Government who becomes, by doing so, the main stakeholder and actor of the country's ICT Ecosystem. This confirms previous research that identified the state as an operator in the ICT ecosystem (Binsfeld, Whalley, & Pugalis, 2016a).

5. The e- skills issue

An important underlying driver for the success of the aforementioned initiatives will be the availability or otherwise of a series of underlying skills and competences. Unfortunately, as reported in, for example, Binsfeld, Whalley, & Pugalis (2016a), Luxembourg, like many other European countries, is facing a substantial lack of ICT and more generally Science, Technology, Engineering and Mathematics (STEM) skills. The different stakeholders in the ICT Ecosystem (see Figure 9) (Binsfeld, 2018) are well aware of this this issue with the consequence that Digital Luxembourg has recently published a national digital skills strategy (Digital Luxembourg, 2019b). This strategy endeavors to address this challenge, the success of which is central to achieving the successful implementation of the initiatives outlined in Section 4 (above).

This strategy, which is multi-pronged in character, is intended to address the broad range of ICT skills that are needed:

- Basic digital skills that range from using a keyboard to operating touch-screen technology, software (e.g., word processing, managing files on laptops, managing privacy settings on mobile phones), and basic online operations (e.g., email, search, or completing an online form). Basic skills enable citizens and employees to interact with others and access government, commercial and financial services;
- ICT specialist skills to develop, operate and maintain ICT systems. This is targeted towards those whose core job consists of ICT;
- Data specialist skills to produce, analyze, interpret and visualize large amounts of data;
- Advanced digital skills linked to numeracy involves STEM graduates who use algebra, formulas, advanced mathematics or statistics in a technology-rich environment.

¹⁰ See <u>https://spaceresources.public.lu/en.html</u> accessed 18.5.2019

¹¹ See <u>https://space-agency.public.lu/en.html</u> accessed 18.5.2019



Figure 9 - Stakeholders of the ICT Ecosystem in Luxembourg (source: authors' compilations

A number of actions have been identified that it is felt are essential for improving, in the medium and long-term, the skills challenge faced by Luxembourg. These actions involve efforts common to both public and private stakeholders and are briefly outlined below:

- 1. A detailed assessment of the skills needed, and an inventory of current and future job roles linked to an improved communication about the roles to the public and, more specifically, future students.
- 2. Adpating and improving the educational system through, for example, developing teacher's digital skills, using innovative learning platforms, introducing coding courses for all pupils, more precise evaluation of the skills levels of students and a better collaboration between schools and businesses.
- 3. Citizens should be able to take full advantage of public digital services. All of the population should be aware of both the potential and risks of using digital technologies. This should include elderly people.
- 4. Different channels for delivering digital skills training, including technical and vocational training, coding boot camps, employer-led training, makerspaces and peer learning should be developed to train the workforce.
- 5. Finally, coordination across a range of education and training institutions, employers, social partners and social institutions is needed to remove the barriers to adult education and training, especially for individuals with low skill levels.

This national skills strategy has just been released and is currently being discussed with relevant stakeholders. It is hoped that this discussion will ultimately improve the skills situation within Luxembourg. However, it must be noted that many, if not most, of these proposals are likely to take a long time before they become effective.

6. Discussion and conclusion

Our analysis finds that although the actual size the ecosystem has not demonstrated growth in recent years, largely due to the decline in e-commerce activities, it remains a core component of the Luxembourg economy. The current structure of the ICT sector, where many companies are small- or medium-sized enterprises with 50 or less employees and micro-enterprises play a prominent role, offers fertile ground for future growth. To this end, the Government has undertaken a range of initiatives whose aim is to stimulate the further development and growth of the ICT sector in Luxembourg.

Luxembourg was amongst the first EU members to see the importance of the data economy, establishing a 'high performance computing' project to position the country at the forefront of developments (Ministère de l'Economie, 2018). Furthermore, Google has announced a project to build one of its biggest data centers in Europe in Luxembourg (Léonard, 2019). While these initiatives grab the headlines, it remains to be seen whether the government's support for high performance computing will result in socio-economic benefits. Moreover, Google has yet to start building its data center and will be several years before the benefits of this investment will be felt.

The Government has also sought to capitalise on the country's strong financial sector through launching a series of initiatives in the areas of cybersecurity (Digital Luxembourg, 2018a), fintech (Gray, 2017) and blockchain (Kshetri, 2017). More recently, the Minister for the Economy has announced the government's interest in developing the space sector through the creation of Luxembourg's space agency (Luxembourg Space Agency, 2018; Luxembourg Space Cluster, 2015).

It has, however, become increasingly apparent in recent years that these different infrastructure projects needed to be supported by underpinning investments in e-skills and competences. Quite simply, Luxembourg lacks the appropriate workforce to actually deliver these projects (Binsfeld, 2018; Binsfeld et al., 2016c; European Economic and Social Committee, 2018). With this in mind, several projects have been initiated by the Ministries of Education and Labour to develop the necessary skills within the country (Ant, Goetzinger, & Binsfeld, 2016; Digital Lëtzebuerg, 2016; Gouvernement du Luxembourg, 2015; Ministry of Labour, 2018). It will take, however, several years before the full (positive) impact of these initiatives will be felt. This raises the question as to what Luxembourg should do in the meantime – importing skilled labour into the country is an obvious solution to the problem, but the extent to which this will be successful is debatable as it places Luxembough in competition with other countries¹².

The Government plays a pivotal role in encouraging and shaping innovative processes within the ICT sector of Luxemobourg. Recently two further initiatives in relation to artificial intelligence (Digital Luxembourg, 2019a) and the data economy (Mario, Crean, & Boever, 2019) have been proposed by the Prime Minister and his deputy, the Minister of Economy. These have been complemented by investment plans announced by major international ICT players like Google (datacenter project), Microsoft (to launch an Artificial Intelligence Academy¹³) and Cisco which recently announced a country digital accelerator plan for Luxembourg (Raizer, 2018) – these companies have been attracted to Luxembourg by the government's initiatives. They are, as a consequence, starting to support the local efforts that are being made. As more players enter the market and the supportive underpinning role of ICT for other parts of the economy is recognised, the ability to coordinate across government and between the private and public sectors comes to the fore. Although the Government has

¹² See <u>https://www.insead.edu/news/2019-global-talent-competitiveness-index-nurturing-</u> entrepreneurial-talent-identified-as-key-to-competitiveness accessed 7.6.2019

¹³ See <u>https://aischool.microsoft.com/en-us/home</u> accessed 7.6.2019

established a new ministry – the Ministry of Digitalisation – to coordinate its actions, it remains to be seen how successful this ministry will be in practice.

Although it has been argued that infrastructure, usage and skills are equally as important as one another (International Telecommunications Union, 2015), a strong argument can be made to say that Luxembourg has focused more on infrastructure than the other areas. One reason for this is that the 'end product' of any investment – computers, data centers, 5G – are easy to observe unlike improved digital skills, while another could be that domestic politics have affected where investment goes. However, recent announcements and initiatives by the Government would suggest that its attention has shifted towards developing the necessary skills that society and the economy needs. Not only are these more difficult to measure, but their development will take several years as well. In addition, a quickly changing technological environment could make any newly developed e-skills rapidly redundant. This necessitates the regular evaluation of the requirements and a highly adaptive skills development process to be developed. The digital skills strategy document - Digital Luxembourg (2019b) - does not yet take into account these dynamics, and as yet does not involve all of the relevant stakeholders.

Assessing whether the skills available within the Luxembourgish economy has improved will require data. The availability of data, not only relating to skills but the socio-economic impact of ICT, is an important issue that needs to be addressed. In the course of updating our understanding of the ICT ecosystem within Luxembourg, it has become clear that data is lacking or missing in a number of areas. More data is required regarding the profitability of companies as well as how much they spend on research and development; without this data, it is not possible to further our understanding of how the various components of the ecosystem interact with one another. Unsurprisingly, therefore, it is not possible to fully utilise Fransman (2018) to map out and then understand how the ICT ecosystem within Luxembourg has developed let alone how innovation occurs. As the various initiatives outlined above clearly demonstrate, the Government plays a key role in the ecosystem, one that is arguably not recognized by Fransman (2018). The pivotal role played by the Government in stimulating the development of the econsystem questions the sustainability of this approach. While it is presently unclear how the Government's role will change, it is reasonable to believe that changes will be prompted by a combination of (financial) resource constraints on the one hand and the increasingly complex and diverse nature of the sector that is reflected in, among other things, the need for a broader array of skills. There will come a point when the Government's ability to actively lead initiatives will change, becoming more of a co-ordinator of activities undertaken by others than it currently is.

Even so, our analysis has shed some light on the structure and development of Luxembourg's ICT ecosystem. Repeating the exercise in another couple of years would further our ability to comment on the dynamics of the ICT sector, which would be particularly informative if the relatively recent focus on skills can be included in the analysis. Of particular interest here would be whether Luxembourg has been able to enhance its ICT skills vis-à-vis other (neighbouring) countries. Notwithstanding it high per capita GDP, Luxembourgh is a relatively small economy and country. While this smallness may facilitate coordination within and between Fransman's (2018) four layers by the government, it also presents challenges as well. When it comes to recruiting international labour possessing the necessary skills to develop its ICT sector, Luxembourg is competing against cities like Amersterdam, Berlin and London. Furthermore, other countries may have more financial resources or be the home market of structurally important companies, with the consequence that they are more attractive to internationally mobile employees than Luxembourg is.

Luxembourg's smallness may, however, enable it to be nimbler than its larger rivals, spotting and then exploiting opportunities that enable the country to be disproportionately influential in certain markets. Two examples that suggest, albeiit tentively, that this may be a fruitful strategy to purpose are Luxembourgh's investment in high performance computing on the one hand and space mining on the other.

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