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# ICT ecosystems in small countries: an analysis of Luxembourg

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## Abstract

*Purpose:* Information and communication technologies (ICT) are increasingly becoming an important component of economic development. ‘Ecosystems’ are one way of understanding complex interactions and relationships. Luxembourg’s ICT sector is usually characterised as performing admirably - it is often at the top-end of different indices and international league tables. Nevertheless, headline statistics and high-level assessments often disguise the complexities of dynamic relations. It is in this respect that this paper deploys the concept of ecosystems to investigate Luxembourg’s ICT sector.

*Design/methodology/approach:* The layered ecosystem model, devised by Martin Fransman, is utilised to map key actors that comprise Luxembourg’s ICT ecosystem, following which a programme of semi-structured interviews were conducted. This empirically produced material, combined with documentary analysis, provides the basis for an analysis of the interrelated elements that are shaping the development of Luxembourg’s ICT ecosystem.

*Findings:* The study has identified the main forces that affect the ICT ecosystem and concluded that Luxembourg’s strengths are related to its well-developed ICT infrastructures such as international fibre and national ultra-high broadband connectivity and high quality datacentres and its political vision for ICT that has led to a supportive policy environment. Its main weaknesses are related to an inappropriate educational system in which technical and scientific training is less developed, missing e-skills such as coding, application development, technical IT know-how as well a non-entrepreneurial mind-set and a risk averse culture.

*Social implications:* The paper highlights the importance of the different socio-economic, political, strategic and technological forces that shape the ICT ecosystem of a small country in order to provide a comprehensive basis for its policy makers.

*Originality/value:* An empirical focus on a small country helps to redress the research imbalance, whereby small countries are often overlooked by scholars. Nevertheless, we contend that such “smallness” engenders a unique opportunity for research engagement with a majority of primary actors in ecosystems, which might be unfeasible in larger countries.

**Keywords:** ICT ecosystems, Luxembourg, qualitative analysis

## 1. Introduction

Luxembourg has one of the most developed telecommunications infrastructures within the European Union (European Commission, 2013a). Broadband and Next Generation Networks (NGN) are available to 100% of the population. The latest mobile networks technologies are present almost everywhere and the country operates about 20% of the world's high resilience datacenter capacity (Luxembourg for Business, 2013). According to the Ookla netindex<sup>1</sup>, Luxembourg is positioned 9th out 113 countries with mobile download speed of 23 Mbits/s, and 19<sup>th</sup> out of 202 countries with about 40 Mbits/s download speed in fixed networks.

This paper builds on the definition of the Information and Communications Technologies (ICT) sector and the underlying classification put forward by OECD (2011) for “measuring the information society”. This definition of ICT includes IT goods and services, Information content as well as Telecommunications goods and services including manufacturing and production of these. Information technologies and e-commerce are seen as growth areas for Luxembourg (PWC, 2011). ICT technologies are widely used by households and businesses, about 17.000 people work directly in ICT and many more in the related financial industry. Over the last 15 years, governments have supported the development of the ICT sector as a policy maker, as a regulator but also as ICT service provider as the Government is a 100% owner of two telecommunications operators and has invested directly or indirectly in many ICT related activities. These activities have helped to create a dynamic ICT ecosystem (Rafique, Yuan, Tareen, Saeed, & Hafeez, 2012). In addition, Luxembourg has improved in the last 15 years its relative ratings in international indices, such as, for example, the networked readiness index produced by the World Economic Forum (Dutta, Geiger, & Lanvin, 2015) in which Luxembourg is now placed among the top 10 most “network ready” countries in the world. Nevertheless, Luxembourg's ICT ecosystem also exhibits some frailties not always captured or transparent in international league tables.

This paper deploys the layered ecosystem model approach as proposed by Fransman (2010) as a means to identify the main actors in Luxembourg's ICT ecosystem. Fransman's model has been widely cited and used by many scholars. By applying this model, the authors aim to map the different actors in the ICT sector, analyse the relationships between the actors within the ecosystem in order to better understand how the ICT ecosystem in Luxembourg has developed over the last 15 years and more generally what are the internal and external factors that have helped to shape it over this period in time.

The remainder of the paper is structured as follows. Section 2 presents different approaches to analyse an ICT economy and introduces a specific ecosystem model. Section 3 gives a brief overview of the ICT ecosystem, its size and its main players and presents some of its major developments over the last 15 years. Section 4 argues the case to developing a better understand of the situation by conducting a qualitative exploratory analysis and presents the methodology used. Section 5 presents the initial<sup>2</sup>

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<sup>1</sup> See <http://explorer.netindex.com/maps?country=Luxembourg> accessed 15.5.2015

<sup>2</sup> Work in progress as part of the lead author's DBA thesis

outcomes of this analysis and the final section discusses this outcome and draws some initial conclusions and suggests potential areas for further work.

## **2. From Value chains to Ecosystems**

In order to establish a competitive and sustainable ICT industry it is important to understand its structure, its underlying business relationships as well as the external forces that help to shape it.

There is a wide range of models available to make sense of the structure of the ICT industry. Many of these apply or develop the Porter's value chain to the ICT environment or parts of it (Maitland et al., 2002) or have extended this model to a so-called value net (Li & Whalley, 2002, Peppard & Rylander, 2006, Rafique et al., 2012). This idea which has also been taken up and developed further by for example Hallikas et al. (2008) and Oestreicher et al (2012). Similarly, Porter's model about competitive forces (Porter, 1990) has been adapted to the ICT environment (Karagiannopoulos, Georgopoulos, & Nikolopoulos, 2005). Along the same lines, Briglauer (2004) has developed a generic reference model in order to assess from a regulatory viewpoint competition in different communications markets. Additional work has been done in characterising the ICT Ecosystem as a network (Garcia & Vicente, 2012), as well as looking into how such networks are built and maintained (Partanen & Möller, 2011).

These models are essentially linear ones, but today's business environment is complex and dynamic and presents multiple relationships where companies are interacting to deliver their products and services. As a consequence, the ICT sector is increasingly characterized as a socio-technological system facing asymmetric and delayed feedback structures, which lead to turbulent changes (instability/existence of multiple equilibria) and high uncertainty. Koslowski, Longstaff, Vidal & Grob (2012) see strong indications that ICT ecosystems represent complex adaptive systems as they exhibit several generic properties, for example, emergence, self-organization and non-linearity. They see the ICT sector as an ecosystem as many heterogeneous organisations that are woven into a web of links and respond interactively to forces in the environments. The understanding of the dynamics of one domain in isolation from the other is impossible and demands both, a systemic and evolutionary view.

According to Kim, Lee, & Han (2010) an ecosystem can be defined as an economic community involving many companies working together to gain comparative advantages as a result of their symbiotic relationships. The authors also argued that ecosystems permit companies to create new values that no company could achieve alone. Likewise, they identified symbiotic relationships that can provide some benefits for related parties such as consumers and partners

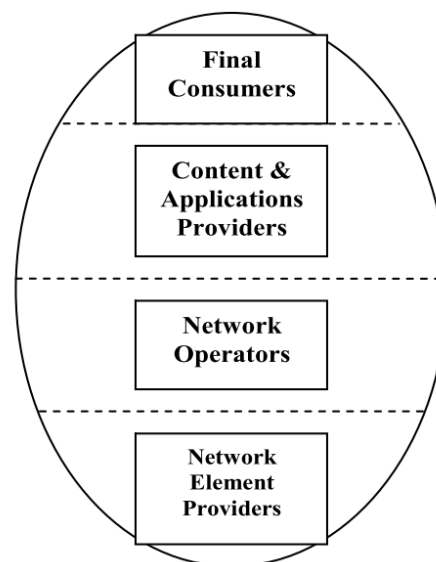
Hence it is important to examine ICT ecosystems in order to understand the co-evolution between technological and economic as well as regulatory forces and developments and to provide a comprehensive basis for policy makers. For the purpose of understanding the structure of the ICT ecosystem in Luxembourg, it is suggested here to use a layer model described by Martin Fransman (Fransman, 2001, 2002a, 2002b, 2004, 2006, 2014). This model allows a clear identification of the different categories of actors within the system as well as the "interfaces" and relationships between those actors and thus provides a simple yet effective way to gain a good

understanding of the different types of actors, their respective roles and importance to the sector as well the interrelations between them

Building on a technical network model<sup>3</sup>, Fransman proposed a 4 layer model to describe and analyse the ICT ecosystem. He deliberately used the term ecosystem (borrowed from biology) to stress the importance of the links between the various ICT actors. When looking at the supply side of the ICT ecosystem, four types of actors can be distinguished (see figure 1):

- Layer I: Network element providers (eg Cisco, Samsung, Alcatel-Lucent, Ericsson, Nokia Networks)
- Layer II: Network operators (fixed and mobile) (eg BT, Deutsche Telekom, Vodafone)
- Layer III: Content & application providers (eg Google, Apple, YouTube)
- Layer IV: Final consumers

In the new ICT ecosystem (ie post-internet), users are gaining presence on the supply side of the system by co-creating with suppliers.

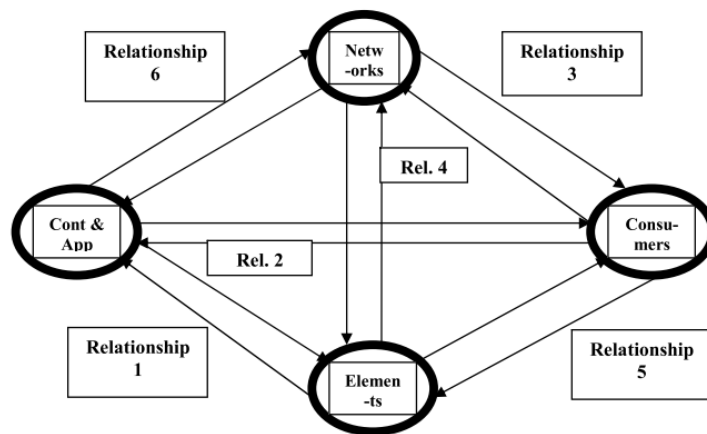


*Figure 1 - the 4 layer model*

In contrast to the so-called “old ICT ecosystem” (ie 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. In recent years, the focus has shifted to the interaction between platform, content and application providers (Layer III).

In his more recent work, Fransman (Fransman 2007, 2010, 2011) has commented on the “necessarily” static picture that such a model provides and has focussed on the role of the dynamic or as Fransman calls them “symbiotic” relationships between the different layers and their role for innovation (Fransman, 2014). These relationships can be described as multi-dimensional representing financial and material flows as well as information and input flows into the innovation processes within the ecosystem.

<sup>3</sup> See <http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=2820> accessed 15.6.2013



*Figure 2 - Relationships within the layer model*

An application of how this model can be used to understand the interactions between different actors is provided by, for example, Arlandis & Ciriani (2010). It also includes a detailed database of players in the different layers and focussed but takes a high level view by looking at different economic cluster such as the EU, the US and Asia.

Another application of the Fransman model can be found in Veugelers (2012). Here the model is used to understand why Europe's ICT companies are lagging behind the US and in particular 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 identified as being the main blocking points.

### 3. Luxembourg's ICT sector

Following the OECD definition of ICT, 7% of the country's Gross Value added is generated within the sector. This share is considerably above the EU-27 average which is around 4.6% of the total GVA and is the highest among the 27 EU member states (European Commission, 2013b). The country has not only a high proportion of highly skilled workers, but has also one of the highest shares of ICT-using occupations among OECD countries. The Luxembourg labour market is characterised by one of the largest shares of knowledge-intensive activities<sup>4</sup> in Europe, with 56% of all the jobs in 2011 falling into this category (Service des Médias et des Communications, 2013).

In terms of computer skills, an European survey on ICT usage in households and by individuals showed that Luxembourg, together with the Nordic countries, features the highest shares of highly skilled computer users in Europe (Service des Médias et des Communications, 2013). Concerning features like Internet skills, participating in social or professional networks, Internet banking, online shopping, ordering goods or services over the Internet, a similar picture of Luxembourg as being part of the leading European nations arises. It shows that e-skills are acquired by individuals to 35% through formal education, 26% through training courses upon demand of their employer, 27% through self-study, 66% through learning by doing, 69% through informal assistance from

<sup>4</sup> An activity is defined as being knowledge-intensive if the tertiary-educated persons employed represent more than 33% of the total employment in that activity (REF NEEDED).

colleagues or friends. Again Luxembourg lies in first or second place of all EU member States.

### **ICT infrastructure and connectivity**

With regard to ICT infrastructure and connectivity (Fransman's layers 1 and 2) Luxembourg has invested considerable efforts to build and efficiently operate multiple state-of-the-art high capacity fibre networks. This is to ensure national and international connectivity, connecting Luxembourg to major hubs in Europe, thereby positioning Luxembourg as a major player in the middle of the so-called 'Golden Ring', which shapes the major Internet hubs of Europe: London, Amsterdam, Frankfurt and Paris (Service des Médias et des Communications, 2013). Also, in terms of communication access paths, Luxembourg occupies one of the strongest positions within OECD countries (OECD, 2013).

By 2009 100% of Luxembourg's population was covered with 3G mobile networks, whereas in 2012 64% of the population were covered by the 4G network. Similar considerations apply to broadband connectivity and will be even further developed, as in its national strategy for very high-speed networks, issued in April 2010 (SMC, 2010a), the Government intends to increase the speeds of the existing networks, and provide, in the medium term, access to optical fibre in the entire territory. It is the Government's intention to transform Luxembourg into the first "fibred" country of the EU, if not in the world. Luxembourg has also grown into the premium location for data centre parks in Europe, with more than 19 data centres are operational, presenting generally the highest securities standards (SMC, 2010b).

With regard to the ICT equipment in enterprises, the aforementioned study, using figures provided by STATEC for 2012, states that among enterprises with 10 or more employees, practically all (98%) have Internet access, virtually all (95%) through a broadband access and many (54%) also through a mobile connection. Three quarters of the enterprises have their own website, 48% an Intranet, 32% an extranet, 16% videoconferencing facilities and among the enterprises using computers 100% worked with a wired local area network (LAN) and 43% had also a wireless local area network (WLAN). It can be assumed that these numbers have since then improved.

### **ICT usage in private households**

The 2015 STATEC bulletin on ICT in households and among individuals in 2014 (Bodson & Frising, 2015), highlights the recent expansion of social networks and cloud activities, especially among young people. In 2014, 60% of residents aged 16 to 74 participated in social networks, of which Facebook was the most popular as 57% of residents were present there, with only 8 and 9% for LinkedIn, Google+ and Twitter combined. Generally customers only consult one social network (64%), with only 36% of users consulting several networks. Not surprisingly, young people are very active: 91% are present in at least one social network against 26% of the 65-74 years category. Social networks are used primarily to maintain existing relationships (82%), to renew past relationships (74%) and share photos and videos (57%). As for the absentees from social networks, they often justify this with their desire to keep their private life to themselves (74%).

The "cloud" also marks a great success as the country moves with 37% of users to the third position of EU28. The cloud is mainly a case for youth with 50% of users and is

linked to the level of education: post-secondary graduates are 44% against 26% for lower secondary graduates and non-graduates.

In comparison to previous studies, this STATEC bulletin states that in 2014 96% of household residents had access to the Internet, an increase of six points compared with 2010 and 26 percentage points compared to 2006. Luxembourg is now positioned at the top of all European countries. The computer remains the number one device for accessing the Internet (87%), followed by the smartphone (70%). Similarly, with regard to online commerce, in 2014 74% of residents made purchases of goods and services on the Internet. This proportion has doubled in 10 years, from 39% in 2005. Among the most common purchases are those related to holidays (vacation dwellings (45%) and transport rental tickets, 39%). Purchases of books and magazines are also common (44%). At a European level, Luxembourg is in fourth position with regard to purchases over the Internet.

### **Government initiatives**

The Luxembourg ICT-stakeholders have recognized the important role that ICT plays in national economic development. Luxembourg has, in recent years, experienced a major advancement with the accelerated development of the country's innovative technology companies, whether in the media sector, e-commerce, digital content, cloud computing, big data or electronic payments (Kitchell, 2010).

A considerable investment has been realised to transform Luxembourg into a highly connected country, while providing the necessary support structures, such as communications infrastructure (connectivity, data centres, security-related services), research and innovation institutions (university, research centres, support to innovative companies, etc.), or adapting the legislative framework for a dematerialized digital society. It was thus possible to create an attractive setting for companies that wish to develop their activities in the country, as well as to provide new employment perspective for highly specialised workers, thereby increasing the competitive as a nation on the whole (SMC, 2010b).

As a consequence, the ICT sector becomes an economic player in its own right and is not merely limited to its function as a services provider to other economic sectors. In both ways, as an economic sector by itself and as a vector of competitiveness for all other socio-economic sectors, the ICT sector will play an important part in the modernisation, performance, competitiveness and efficiency of the country.

In order to strengthen and consolidate the country's position in the field of ICT and to transform its ICT sector into a 'high tech' centre of excellence, the Luxembourg government, in conjunction with its stakeholders, a digital strategy, encompassing subjects as diverse as the computerization of government services, e-skills, the adaptation of financial support instruments, the development of new niche markets for new markets (big data, health technologies, innovation in services to the financial sector ("FinTech"), virtual currency, creative industries, etc.), and the Government accepts this strategy of horizontal and consistently across all its policies that may be relevant (Gouvernement du Luxembourg, 2014b).



## 4. Methodology

Whilst all of the above mentioned facts and figures tend to show that ICT has developed over the course of the last 15 years, it is not clear what have been the main reasons for this relative success and whether this will continue in the future. Therefore, we propose to apply the Fransman model to explore the ICT ecosystem and to identify the different forces and relationships at hand.

In a first step the main categories of actors have been identified in the different layers as well as institutions that shape and influence the relationship between the different layers using a focus group of 9 experts. The outcome of this work resulted in the overview of the ICT sector in Luxembourg that is presented in Figure 3 (below).



Figure 3: Luxembourg's ICT Ecosystem

This model was discussed with different stakeholders and developed by the lead author in an interactive and iterative manner. Focussing on the above mentioned relationships within the ecosystem, it starts by identifying actors at government and political level that shape the regulatory and policy environment for ICT within the framework of the regulatory packages set by EU (European Commission, 2014a). It then identifies the different state-owned agencies and institutions that provide support to the ICT sector in terms of public funding, awareness raising and training (upper box in the model).

The next level identified concerns regulation in the broadest sense, including the National Regulatory Authority, the National Standards Agency, the Data protection commission as well as regulatory authorities for the financial sectors (right box). The ICT ecosystem is also supported by R&D activities and organisations such as

University of Luxembourg, public research centres but also venture capitalists and incubators (lower box).

Looking closer into the system itself, it is possible to identify ICT enablers that provide the underlying infrastructures; this includes network element providers and network operators corresponding to the layers 1 and 2 of Fransman's model. Building on this, one can find the ICT service enablers that would fit within Fransman's third layer and the customers or users of ICT of which some have been identified in the diagram above. Customers are Fransman's fourth layer. These include most of the actors in Luxembourg's well developed financial sector (KPMG, 2013). Finally we can also identify several institutions or organisations, private and public that are active in promoting the sector both nationally and internationally

Building on the figure above, we have chosen to conduct a qualitative exploratory analysis (Cresswell, 2014; Easterby-Smith, Thorpe, & Jackson, 2012) building on extensive unstructured and face-to-face interviews (Schultze & Avital, 2011) with major stakeholders within the ICT ecosystem. The objective was to study the forces that shape the ICT ecosystem, to understand their interactions and to identify its strengths and weaknesses. A two stage approach was adopted, using a focus group consisting of major industry and institutional players in order to establish an initial template through a SWOT analysis (Anderson, 2010; King, 1998). This SWOT analysis was the used to design open-ended questions to start the interviews and to assist in the later coding process of the outcome of these.

Potential interviewees were then identified based on the lead authors' contacts – about 60 people have been identified. Care was taken to have a reasonable sample of actors across all of the different "Fransman layers" as well as institutions and outside "influencers". Only senior decision makers were interviewed, all with many years of experience in ICT and more particular the Luxembourgish situation.

Table 1 below identifies the companies or institutions that have been interviewed, categorised by the different layers identified by Fransman. Requests were made by email and generated a positive response rate of higher than 80%, with additional people contacting the lead author to volunteer to be interviewed. A total of 51 interviews were conducted over a period of 9 months during 2014, roughly one or two per week. Starting usually with "what do you find good or bad about the ICT ecosystem in Luxembourg?" No clear definition of the ICT ecosystem was made but participants often gave their own definition. Interviews took place in a location chosen by the interviewee (mainly their offices) and were recorded. In order to guarantee confidentiality a "non-disclosure agreement" was signed. Initially the interviews were completely unstructured, however, after a first analysis and in order to avoid too much duplication of the same topics, subsequent interviews were semi-structured in order to identify the widest possible range of different views. During the interviews, participants were asked to identify what they considered to be the main strengths and weaknesses of Luxembourg's ICT ecosystem, what according to them has led to the current state of its development and how they thought that the ecosystem was likely to evolve in the future. They were also asked to come up with suggestions for future actions.

The recordings of the interviews, which generally lasted around 1 hour, were then imported into NVIVO, a computer aided qualitative data analysis software to be

processed (Bazeley & Jackson, 2007; Beekhuyzen, 2010; Neill, 2013; Welsh, 2002; Wong, Medicine, & Lumpur, 2008). As NVIVO is able to code data directly in either text, pdf, audio or video files, it was decided to code directly on the audio content, transcribing and translating however the main ideas and topics into text as well. Due to the multilingual workforce of Luxembourg, interviews have been conducted in four languages - Luxembourgish, French, German and English - and were then partially translated. An advantage of NVIVO is that it allows almost instant access to any of the underlying data so that everything that has been said can be traced back directly from coded outcomes.

Fransman's layer	Interviewed Organisations and Institutions	Individuals
I – network element providers	Alcatel-Lucent, Cisco, HP, Unify	4
II – converged communication and content distribution providers	Broadcasting Center Europe, British Telecom, Cegecom/Artelis (2), Eltrona,(2) Fédération des Opérateurs Alternatifs Luxembourg, HotCity, Join Wireless, Post (2), Société Européenne des Satellites, Telecom Luxembourg,	13
III – platforms, content and applications	Association des professionnels du secteur financier, Association des professionnels du secteur de l'information, CTTL, Data4, Datacentre Luxembourg, Ebrc, Itrust, Luxconnect (3), Luxcloud, Netcore, Systemat, Telindus (2),	15
IV – consumers	Appolo Strategies, Association des Banques et Banquiers, Exxus (2), Gartner, Ikano, Fédération des Artisans,,Luxembourg Business Federation, ProNewTech, PwC	10
Outside influencers – finance, regulation, standardisation	Interdisciplinary Centre for Security Networking and Trust (2), Institut Luxembourgeois de Regulation, Luxinnovation, Luxembourg Institute of Technology, Ministère de l'Economie, Moskito, Service des Médias et des Communications	8

*Table 1: Companies and institutions interviewed*

Coding started with the initial template from the aforementioned SWOT analysis but evolved over time. Additional interviews have been conducted until no further new codes or topics arose. Translation, partial transcription and coding took about 3-4 hours per interview. The use of NVIVO gives a lot of facilities, for example it allows immediate display all the codes per interviewee, it allows basic statistical analysis for example on frequency of codes, time spent, how often a certain code or indeed expression has been used. It also allows for a graphical representation of interviews, the topics covered as well as the relationships between codes. Instant access to underlying text, audio, or video files is possible and all raw data are always available.

On the other hand, understanding and setting up the tool can be cumbersome, the raw data generate large files that are difficult to handle, the coding takes a lot of time and is necessarily somewhat subjective. As a consequence, based on some samples – coding verification has been done independently. The tool, however, also has an “autocoding” function that could unfortunately not be used because of the respondents' use of different languages.

## **5. Main forces shaping the Ecosystem**

The following section presents the outcomes of the interviews with the different stakeholders identified in Table 4 (above). It appeared that a majority of interviewees made a difference between factors that Luxembourg and the actors in the ecosystem have some control over (endogenous factors) and those that were “outside” of the system and driven mainly by the wider EU regulatory and geopolitical competitive environment (exogenous factors). Figure 4 (below) presents the different categories of topics that were mentioned as well as the different individual items and their relative importance, whereas Tables 3 and 4 also indicate how often a certain topic was mentioned.

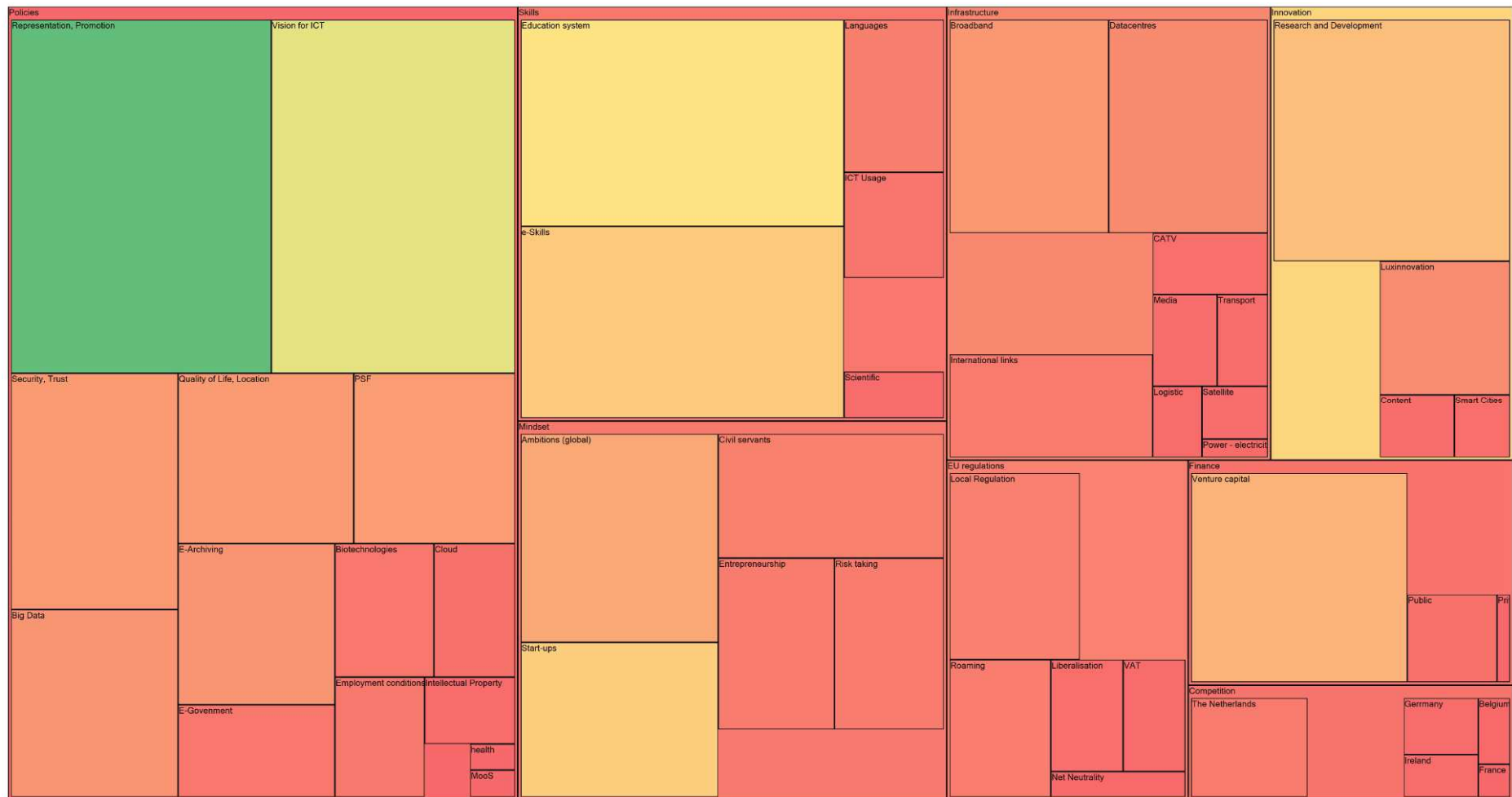


Figure 4 – Forces and specific topics identified by stakeholders

### 5.1. Exogenous Factors

The table below shows the exogenous factors that were mentioned as well as the frequency that they occurred in the interviews.

Exogenous Factors	Identified by stakeholders
<b>Competition</b>	<b>30</b>
Belgium	2
France	1
Germany	3
Ireland	3
The Netherlands	11
<b>Regulations (EU)</b>	<b>66</b>
Liberalisation	7
Local Regulation	21
Net Neutrality	3
Roaming	12
VAT	6

*Table 2: Exogenous Factors influencing the ICT Ecosystem in Luxembourg*

#### The importance of EU regulations

A large majority of the stakeholders are well aware that the local ICT ecosystem is heavily influenced and evolves within the framework of the different EU regulatory packages (see, for example, European Commission, 1987, or European Commission, 2013b) and programmes that have been put in place mainly in order to stimulate competition and the move towards a digital single market (European Commission, 2010). It was felt that often these EU regulations are not working in favour of the ICT ecosystems of small countries and the pressure towards a single EU wide market favours large or indeed global players. In this context, the discussion about reducing or abolishing roaming charges was often mentioned as an example (De Fooz, 2014a; Henry, 2014b) as well as the fact that there exist many restrictions with regards to access to on-line content and geo-blocking applied by major content owners. This prevents local consumer from legally accessing such content (Boston Consultancy Group, 2013).

On the other hand, some stakeholders also mentioned the effect of the different VAT regimes on electronic commerce. This has had, so far, a major positive influence on the development of the industry (PWC, 2011). These stakeholders were also aware, however, that this effect is currently about to disappear in line with EU rules (Post Telecom, 2014).

Many stakeholders also identified issues related to the local implementation of the EU regulations and it amongst others it was felt that national regulatory authority did not actively enough intervene in the market and did not have the necessary resources.

#### Growing international competition

In addition international competition from different EU member states both to attract ICT activities and on the export level have also identified to be increasingly important. In this context, the main competitors identified were the Netherlands, Ireland as well as Luxembourg's immediate neighbouring countries. It was felt that competition was generally becoming more intense and that recent events around "Luxleaks" (Paperjam,

2014b; Raizer, 2014b) as well as Luxembourg's image as a "tax heaven" were negatively affecting Luxembourg's position (Guardian, 2014). It also becomes increasingly difficult to identify and communicate Luxembourg's unique selling points, with some actors commenting that a new marketing and communication strategy might be needed (Bervard, 2015; Fondation Idea, 2014; Gouvernement du Luxembourg, 2014).

Overall, participants felt that both of these sets of external factors had a major influence on the ecosystem and suggested that Luxembourg, due to its small size, might be more vulnerable or exposed to these forces that the Fransman model gives less emphasis to.

## **5.2. Endogenous Factors**

Table 4 below shows some details of the endogenous factors that were mentioned by the different stakeholders as well as their frequency. The list of these factors is much longer and it will not be possible to address them in depth here. Thus, only a broad overview will be provided below (by order of the importance expressed by the number of times a certain topic was mentioned).

### **Government Policies**

A wide range of different policy initiatives have been identified and commented on. There was a large and general agreement that successive governments had taken ICT seriously and developed, as expressed by the World Economic Forum (Dutta et al., 2015), a "vision for ICT" and launched a wide range of initiatives that have helped the sector to develop. It was felt, however, that more could have been done in terms of marketing and promotion of Luxembourg to the outside world and that the sector also needed a more coherent approach in terms of its representative bodies. Indeed, too many associations, forums, federations, clusters and agencies are claiming to represent their individual members' interests, but there is a lack of overall representation of the sector, both nationally as an interface to policy makers and internationally. In that respect, participants welcomed the recent creation of an overarching federation called ICT Luxembourg (Gaudron, 2014) as well as a new government strategic plan called Digital Lëtzebuerg (De Fooz, 2014b; Land, 2014) and expressed their hopes (and fears) that these initiatives might improve the situation.

Many participants, and in particular foreigners working and living in Luxembourg, identified its smallness as a major factor. This smallness leads to a very high quality of life (low pollution, safety, nature, high standard of living) and, most importantly, to easy access to political decision makers implying the potential to react flexibly and quickly. On the other hand, many stakeholders also mentioned that this high standard of living also leads to very high living costs and consequently of employment. In particular, housing has become extremely expensive making it difficult for young entrepreneurs to move to Luxembourg (Sorlut, 2014). Several individual government initiatives were positively commented on. These included the creation of a specific status and certification for services providers to the financial sector (Deloitte, 2013), the focus on security, trust and data protection (Trân, 2013), initiatives around the usage and exploitation of big data (KMPG, 2014) and the legal framework on intellectual property rights (Raizer, 2014a).

<b>Endogenous Factors</b>	<b>Identified by stakeholders</b>
<b>Finance</b>	<b>59</b>
Private	1
Public	7
Venture capital	40
<b>Innovation</b>	<b>89</b>
Content	4
Luxinnovation	15
Research and Development	49
Smart Cities	3
<b>Mind-set</b>	<b>131</b>
Ambitions (global)	35
Civil servants	24
Entrepreneurship	17
Risk taking	16
Start-ups	26
<b>Policies</b>	<b>326</b>
Big Data	25
Biotechnologies	11
Cloud	9
E-Archiving	21
E-Government	12
Employment conditions	9
Health	5
Intellectual Property	5
Mini One Stop Shop for VAT	1
Professional of Financial Sector	23
Quality of Life, Location	25
Representation, Promotion	77
Security, Trust	33
Vision for ICT	72
<b>Skills</b>	<b>144</b>
Education system	57
e-Skills	53
ICT Usage	9
Languages	13
Scientific	4
<b>Infrastructure</b>	<b>118</b>
Broadband	29
CATV	6
Datacentres	29
International links	18
Logistic	3
Media	5
Power – electricity	1
Satellite	2
Transport	4

*Table 4: Endogenous factors identified by stakeholders*

However, some people commented negatively on the fact the Luxembourg had still not managed to create a legal framework for “e-archiving” (Cencetti, 2014a; Ministère de



l'Economie et du Commerce Extérieur, 2013). Some participants also felt that more could have been achieved in terms of “e-government” (Gouvernement du Luxembourg, 2005) and “e-health” (Henry, 2014a; PWC Luxembourg, 2013). It was also suggested that too much effort was focused on biotechnologies (Gouvernement du Luxembourg, 2013). A handful of participants suggested initiatives to fill these gaps.

### **Education and e-skills**

The interviewees also insisted on the importance of relevant skills, both on a technical and scientific level but more generally the e-skills necessary to make the best use of ICT. It was found that Luxembourg has performed particularly badly on these “softer” elements. Participants actually complained about the fact that it became increasingly difficult to recruit the necessary employees on the local and even regional market, and that substantial effort was needed to attract such employees to Luxembourg. One or two actually identified missing e-skills as a major hindrance to their further development. Several national studies are available to confirm this situation (Fedil, ABBL, & CLC, 2014; Gouvernement du Luxembourg, 2011) but this is also a major issue in surrounding countries and generally in Europe (European Commission, 2014b; Gareis et al., 2014).

On the other hand, participants mentioned the lack of appropriate training and education within Luxembourg both in terms of software programming but also more generally in terms of technical and scientific education (European Schoolnet, 2012). Some also commented more generally on the efficiency and effectiveness of Luxembourg’s educational system, a system that is based on “tri-language” education and which needs some adaptations in the light of the quickly evolving social and technological environment (Gouvernement du Luxembourg, 2014a; OECD, 2014). Many of the participants highlighted the urgency of this issue and hoped that the government’s new strategic plan would help to ease the situation (De Fooz, 2014c).

### **Mind-set**

Stimulating entrepreneurship and facilitating the creation of start-ups are also important element of success. It was found that Luxembourg lacks both the necessary processes and procedures but, more importantly, an entrepreneurial mind-set. Participants also identified a general mind-set issue in terms of the risk awareness particularly of the local population. Indeed a lot of young people prefer a job as a civil servant in an administration or local community to – sometimes less well paid – jobs in private sector.

### **Infrastructures**

Developing ICT infrastructures has been confirmed as an important building block for a successful ICT ecosystem. Participants agreed that Luxembourg has been doing very well on these elements, with extensive high-quality, high-resilience data centre capacity (Service des Médias et des Communications, 2013), low-latency international connectivity and broadband internet access are in place and used both by private individuals and professionals. These need to be supported, however, by investments in complementary infrastructures such as transportation (Antzorn, 2014a) and energy distribution networks (ILR, 2013).

Some participants made critical comments about unused capacity, both in terms of international communication links and data centres and mentioned the lack of space for larger data centres of a lower quality standard (Labro, 2015). Some also suggested that

perhaps too much focus had been given to providing fibre connectivity to each household as part of the government's broadband strategy (SMC, 2010a). A more focussed approach, making more use of the already existing CATV networks, might have been more effective (Henry, 2013; OPAL, 2013).

### **Innovation**

Luxembourg's university, which is only 10 years old, was felt by many participants not yet to be fully aligned with the requirements of Luxembourg's economy (Paperjam, 2014a). It was also suggested that the same was true for the country's public research centres (Lambotte, 2014b). Technical, and in particular ICT education programmes, are missing or very narrowly focused. There is also no business school attached to these programmes.

There also have only very limited creations of spin-offs or start-ups through these institutions. It was also felt that organisations facilitating these processes were not working efficiently (Cencetti, 2014b; Luxinnovation, 2013; Machuron, 2014) and that better coordination between them was needed. Many of the statements made have been recently confirmed in an OECD study about innovation policies in Luxembourg (OECD, 2015).

### **Access to financing**

Luxembourg's financial centre is very well developed (Bourgain, Pieretti, & Høj, 2009; Merker, 2013) and this may explain that access to finance was not generally found to be major issue (IT One, 2014). Access to initial, high risk, venture capital was identified as being of some importance but overall the main problems seems to be the lack of initiatives and ideas for new start-ups rather than their financing (Antzorn, 2014b; Lambotte, 2014a; Machuron, 2014)

### **Industry structure**

Participants were also asked how they saw the structure of the market following several years of liberalisation and privatisation efforts. It was felt by the participants to be very important to have an adequate mix of public and private investments, but that the incumbent operator after years of liberalisation of the market was still very dominant. This could prevent both local investments as well as foreign direct investment par major ICT or telecommunications actors.

Figure 5 (below) summarises the main findings of the analysis. These have been derived using an inductive approach from the statements made by the interviewees. Interviewees have identified the different underlying internal and external forces. For some factors (green) the participants felt, overall, that Luxembourg was performing well and that the ICT infrastructure as well the governments' "vision for ICT" were considered to be particular strengths of Luxembourg. Educational topics, e-skills and the missing "entrepreneurial mindset" were identified as major weaknesses. Growing international competition was identified as the main external threat that the ecosystem is currently facing.

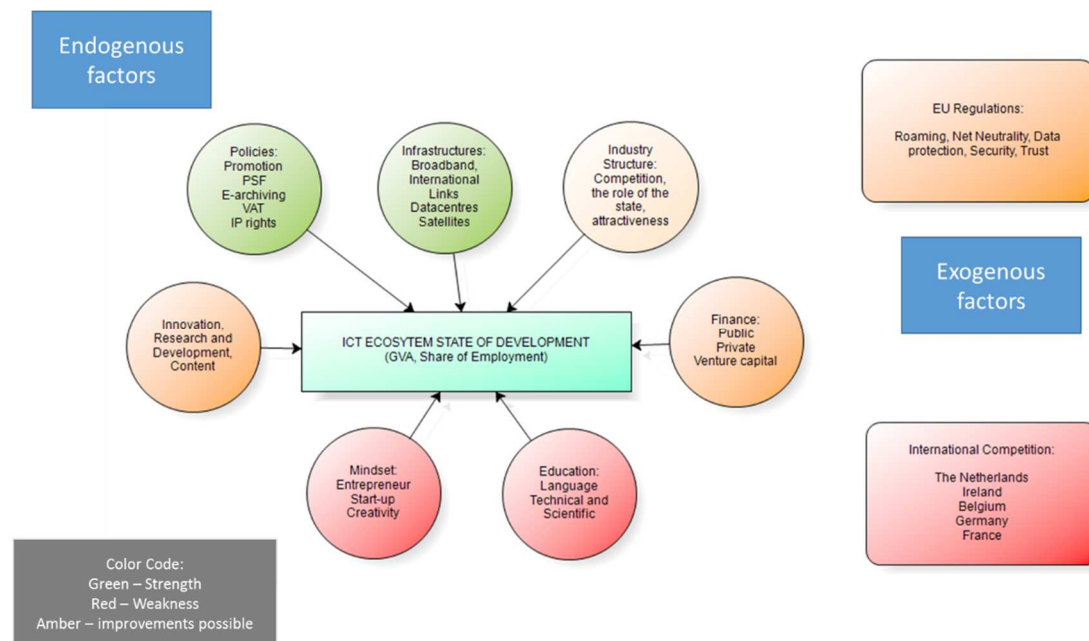


Figure 5: Overview of factors influencing Luxembourg's ICT Ecosystem

## 6. Discussions and conclusions

In this paper we have employed the layered model of Fransman to identify major industry participants within the different layers. An exploratory qualitative analysis building on interviews with over 50 participants in the ICT ecosystem in Luxembourg were undertaken.

These participants confirmed that, according to them, Luxembourg has been successful in developing its ICT sector over the past 15 years, which is reinforced by international rankings and comparisons, and 'official' reports. The government's initiatives have contributed to developing the underlying ICT infrastructures in terms of international connectivity, broadband and ultra-high broadband access as well as datacentre infrastructures. They also confirmed that the industry structure has changed over time and that competition in several segments of the sector has increased. This competition has resulted in innovative products and services being offered at appropriate pricing levels, and these services have been adopted by both private users and enterprises. This, in turn, has led to the creation of jobs and added value for Luxembourg's economy.

On the other hand, participants acknowledged that new challenges have appeared over time and that past policy initiatives may not be enough to sustain present competitive advantages. Clearly, Luxembourg is impacted by changes in EU rules and regulations which make it increasingly difficult to offer financial or tax advantages to companies investing in Luxembourg, and the government has faced some strong international pressures recently in that respect (Lecadre, 2014; Paperjam, 2014b; Raizer, 2014b, 2014c, 2014d). Consequently, it becomes more difficult to position Luxembourg successfully in the context of increased EU and even global competition and Luxembourg needs to make changes to its ICT ecosystem.

Many factors could potentially contribute to the creation of 'unique selling points' for Luxembourg, but participants expressed concern that Luxembourg has been over reliant on developing its ICT infrastructures in terms national and international fibre

connectivity and datacentres. Derived from interviews, we have identified many additional factors that also need to be further developed and that Luxembourg has been unable, to date, to institutionalise an educational framework equipped to “produce” the necessary IT skills on a local basis due to a natural inertia in adapting the curriculums. Instead it has relied on “import of knowledge” from neighbouring countries, whilst focussing on its language skills and legal, financial and humanities education. Different initiatives are now under discussion both on the supply side (new training programmes, private schools, professional development) and on the demand side (promotion of Luxembourg as an attractive place to live and work) but all of these will take time to become embedded.

On the other hand, innovation, entrepreneurship, the willingness to take risk and to start new ventures also appears to be underdeveloped. This might necessitate changes to innovation policies and R&D orientation, as well as a re-engineering of the legal and regulatory environment to help better facilitate the creation of start-ups.

Overall, the case of Luxembourg illustrates that it is important to examine the exogenous and endogenous dynamics of ICT ecosystems, which can reveal some nuances erased from international indices and high-level analyses, which could aide policymakers. The above analysis provides a first step and part of a wider effort to better understand the ICT ecosystem in Luxembourg, or in other small economies, albeit the analytical formulations remain provisional as research is on-going. Indeed, there is a need for deeper analysis of interview material.

The paper has benefitted from applying Fransman’s model, which proved useful in identifying key stakeholders. Nevertheless, it does not allow the identification of all of the different subcategories in the different layers that might have substantially different views and requirements. It is, by its nature static and does not adequately cope with the dynamics of the ecosystem and recursive interrelationships that are manifold even during the short period covered by the study. Moreover, stakeholders can be – and are often – main players in one, two or even more of the different layers and adopt a different position depending on the layer concerned. The model does not in itself give sufficient importance to external factors such as regulations or international competition. It does not, therefore, allow for the positioning of any supporting institutions and supporting agencies, such as for example, “Luxembourg for Business” or the different regulatory bodies as shown earlier in Figure 3.

Limitations notwithstanding, to the best of our knowledge, this is the first time that an in-depth analysis of Luxembourg’s ICT ecosystem has been performed. This helps to redress the research imbalance, whereby small countries are often overlooked by scholars. Nevertheless, we contend that such “smallness” engenders a unique opportunity for research engagement with a majority of primary actors in ecosystems, which might be unfeasible in larger countries. Comparative analysis of the ICT ecosystems of small countries might be an interesting avenue of further research.

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