THE DATA-DRIVEN INNOVATION STRATEGY FOR THE DEVELOPMENT OF A TRUSTED AND SUSTAINABLE ECONOMY IN LUXEMBOURG

THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG
Ministry of the Economy

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PREFACE

The progress of digitalization takes a predominant role in the development of today's economy. The unprecedented growth of digital technologies and their interdisciplinary applications are impacting all economic sectors in advanced nations around the world. Digitalization revolutionizes the way to do business; it offers enhanced capabilities and allows delivering solutions with an unmatched speed and flexibility, while often reducing overall costs and environmental impacts.

Given this, Luxembourg strives to seize the latest digital technological developments to achieve the digital economy of tomorrow. Our approach to this transformation is holistic, in the sense that it does not only cover strategic adoption, but also includes developing appropriate skills and building infrastructures and ecosystems as well as designing efficient policies and support in order to ensure a sustainable development.

It is a priority of the Ministry of the Economy to boost the digital transformation of the national economy. The aim of this "Data-Driven Innovation Strategy for the Development of a Trusted and Sustainable Economy" is to lay out the vision of digitalization for priority economic development sectors. It addresses the assets and policies the Ministry of Economy will leverage in order to support the further emergence of a trusted data-driven economy in Luxembourg and accelerate the digital transformation of its strategic sectors. Our aim is to boost productivity and sustainable development across the whole Luxembourg economy.

The Ministry of the Economy has already made several strategic steps to unlock the opportunities of digitalization, specifically in the sector of tourism as well as in the craft industry and retail trade.

The Tourism Strategy 2022 sets a vision and a framework for the development of the Luxembourg tourism sector including the implementation of digital solutions.

In a dedicated development framework for the sector of the craft industry and retail trade, two separate action plans detail how small and medium-sized enterprises from both sectors can seize the opportunities available in a dynamic and digitalized economic environment. These "Pakt PRO Commerce" and "Pakt PRO Artisanat" strategies each address the digitalization of their sector. The strategies fit in the broader framework of the SME action plan.

These development plans, in close synergy with the Artificial Intelligence strategic vision from the Ministry for Digitalisation and combined with this data-driven innovation strategy, form a full-fledged data-driven innovation strategy for the Luxembourg economy. They ensure that all companies benefit from dedicated support and favorable framework conditions to become digitally competitive actors.

The Ministry of the Economy is confident that Luxembourg's competitive business environment with state-of-the-art digital infrastructures and smart policies will allow the Grand Duchy to become an innovative forerunner in the data-driven economy.

1 INTRODUCTION

Digital technologies and platforms are transforming the lives of our citizens, the way they work and how they communicate, as they become more integrated across all sectors of our economy and society. This is part of a global phenomenon as general-purpose digital technologies, such as computing hardware and artificial intelligence coupled with internet of things (IoT), smart networks and Big Data, diffuse rapidly, their uptake accelerates and resulting enabled digital platforms revolutionise markets. A year ago there were approximately 18 billion devices connected to the Internet, by 2025 that figure will increase to 80 billion, at a rate of 150,000 a minute. Today, there are more mobile connections than there are people on the planet. Digital platforms today underpin the business models of some of the world's biggest, fastest growing and most powerfully disruptive companies from Amazon and Google to Uber and Airbnb across very different sectors. Reflecting this, cross-border flows of digitally transmitted data account for more than one-third of the increase in global GDP since 2014 with the Big Data sector growing by 40% per year [1]. This digital revolution will boost productivity across all sectors and industries of modern economies.

This digital transformation is happening at a scale and speed that brings immense opportunities for innovation, growth and jobs in Luxembourg [2]. However, the emerging "Data-driven economy" constitutes both an opportunity and a competitive challenge. The opportunities will come predominately to those nations that are best prepared and equipped to compete digitally. In short, as we will enter the third decade of this 21st century, digital data, digital infrastructure and digital knowledge will be considered as strategic economic and competitive assets in all advanced nations.

Luxembourg has already recognised this fact, as reflected in the Digital Lëtzebuerg initiative, in the strategic study on "the Third Industrial Revolution" [3] that culminated in a vision, narrative and strategic orientation plan to usher in a smart green digital Luxembourg society and in the digital focus of the Luxembourg Smart Specialisation Strategy (RIS3) [4]. The investments made over the last years in digital infrastructure have placed Luxembourg in the number 2 ranking within the European Union in terms of Connectivity [5].

Most recently, the Luxembourg Ministry of the Economy initiatives on High Performance Computing (HPC) and Big Data, the new building blocks of digital infrastructure competitiveness, have resulted in Luxembourg designated as the host location for the headquarters of the future multi-billion euro European Commission Joint Undertaking EuroHPC agency [6].

In parallel, a new Artificial Intelligence strategic vision for Luxembourg will further support Luxembourg's ambition to be amongst the most advanced digital societies in the world.

Governments that are digital innovators today recognize that public policy is essential to the success of the data-driven economy. Countries with high-performing digital sectors typically have strong government involvement in shaping their digital economies. The challenge is to devise policies and regulatory frameworks that allow Governments to fully exploit the ongoing digital transformation, that provide security and trust, whilst at the same time supporting efficiency and innovation. This must be coupled with innovative approaches to computing, data processing and energy efficiency, to minimise energy consumption, ensure energy sustainability and thus a future Luxembourg sustainable data-driven economy.

This document produced by the Directorate General for research, intellectual property and new technologies within the Ministry of the Economy, proposes a vision and path forward, a data-driven innovation strategy, for the Ministry of the Economy as well as for the Grand Duchy of Luxembourg. It addresses the digital innovation policies and infrastructural assets necessary to both support the emergence of a Luxembourg secure and trusted data-driven economy and to accelerate the Digitalization-enabled transformation of its industry across key strategic sectors, boosting productivity across all of the Luxembourg economy.

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1 *The Big Data sector growth rate of 40% per year is seven times faster than the IT market.*

2 *"Digitizing Europe", The Boston Consulting group, May 2016*

3 *Undertaken by the Ministry of the Economy, the Chamber of Commerce and IMS*

4 *Luxembourg Research and Innovation Smart Specialisation Strategy, December 2017, https://gouvernement.lu/fr/publications.html and http://s3platform.jrc.ec.europa.eu/regions/LU/tags/LU*

5 *https://ec.europa.eu/digital-single-market/en/desi*

6 *EUROHPC, http://eurohpc.eu/web/guest*

2 EUROPEAN DIGITAL POLICY CONTEXT

It is now recognized that public policy is essential to the success of a 21st century digital economy. Countries with high-performing digital sectors typically have had strong government policy involvement in catalysing and shaping their digital economies.

"Digital" policies need to be adopted for public-private partnerships on digital innovations, improving access to capital and digital infrastructure, digital data regulation, and support for integration of digital technologies into the legacy economy (amongst others).

In this context, it is appropriate to review the European Digital context within which Luxembourg operates. The European Commission has recognized that achieving a Digital Single Market (DSM) in Europe is a prerequisite for attracting investment in digital innovations and for faster business growth in the digital economy. During 2015-2016, the European Commission initiated an ambitious strategy to achieve a DSM, based around a series of initiatives on the European Cloud and Digitising European Industry. The key European Commission communications framing this European Digital Agenda are:

The Communication on "A Digital Single Market Strategy for Europe" (6/5/2015)

This focused in particular on building a data economy stating " Big data, cloud services and the Internet of Things are central to the EU's competitiveness. Data is (…) a catalyst for economic growth, innovation and digitization across all economic sectors "

This communication also addressed the importance of the free movement of data and proposed a "Free flow of data" initiative to address issues "of ownership, usability and access to data in situations such as business-to-business. Business to consumer, machine generated and machine-to-machine".

The Communication on the "European Cloud Initiative: Building a competitive data and knowledge economy in Europe" (19/4/2016)

A key element of this communication was the focus on implementing a "European Data Infrastructure". The regulation emphasized that "Europe needs integrated world-class HPC capability, high-speed connectivity and leading-edge data and software services for its scientists and for industry (including SMEs) and the public sector". This infrastructure will allow fully unlocking the value of Big Data and digital by default. It stated, "The European Data Infrastructure will gather the necessary resources and capabilities, to close the chain from research and development to the delivery and operation of the exascale HPC systems codesigned between users and suppliers. This will include data connectivity and Big Data storage to make sure that supercomputing services are available across the EU, no matter where supercomputers are located". The communication noted, "A first step was recently taken by Luxembourg, France, Italy and Spain, with their Important Project of Common European Interest (IPCEI) on HPC and Big Data enabled applications".

The Communication on the "Digitising European Industry" (19/4/2016)

The stated context to this communication was the fact that "a key success factor for reaping the full benefits of a DSM is a highly competitive digital industry in Europe and the integration of digital innovations in all sectors. Embracing digital technologies will help companies to grow beyond the EU internal market and make the EU an even more attractive location for global investments". This was coupled with the realization that "Progress in digital technologies in combination with other key enabling technologies is changing the way we design, produce, commercialise and generate value from products and related services. Advances in technologies such as the Internet of Things (IoT), 5G, cloud computing, data analytics and robotics are transforming products, processes and business models in all sectors ultimately creating new industrial patterns as global value chains shift. The challenge ahead is for the European industry to seize fully and swiftly these digital opportunities". The Communication reflected Member

State views that "an urgent EU-level effort to help coordinate national and regional initiatives to digitise industry is important. Today supply chains span Europe and digitisation raises challenges such as standardisation, regulatory measures and volume of investment that can be only addressed at European level. "

In mid 2018, the European Commission published an additional communication addressing "Artificial Intelligence for Europe" and subsequently proposed a € 9.2 billion investment to create the first ever Digital Europe programme.

The Communication on "Artificial Intelligence for Europe" (25/4/2018)

The European Council of October 2017 stated that the EU needed a sense of urgency to address emerging trends such as AI and invited "the Commission to put forward a European approach to artificial intelligence".

The resulting Communication sets out a European initiative on AI, which aims to: Boost the EU's technological and industrial capacity and AI uptake across the economy, both by the private and public sectors, Prepare for socio-economic changes brought about by AI and, Ensure an appropriate ethical and legal framework, in line with the Charter of Fundamental Rights of the EU.

Building on the approach set out in this Communication and the declaration of cooperation signed by 24 Member States, including Luxembourg, on 10 April 2018, the Commission is now working with Member States on a coordinated plan on AI. The discussions take place in the framework of the existing European platform of national initiatives to digitise industry, with the view to agree this plan by the end of 2018.

European Commission Digital Europe programme (06/06/2018)

The European Commission is proposing to create the first ever Digital Europe programme and invest € 9.2 billion to align the next long-term EU budget 2021-2027 with increasing digital challenges. The Commission press release stated "the Digital Single Market strategy established a regulatory framework that is fit for the digital age. This needs to be matched with equally ambitious funding and investments to reinforce Europe's strategic digital capacities". Digital Europe will create the necessary infrastructure, as well as supporting deployment and capacity building, to shape Europe's digital transformation.

The Commission's proposal focusses on five areas:

- **Supercomputers**

  € 2.7 billion will fund projects to build-up and strengthen supercomputing and data processing in Europe. Digital Europe will aim to deploy a world-class supercomputer and data infrastructure, endowing the EU with its own independent and competitive technology supply.

- **Artificial intelligence (AI)**

  € 2.5 billion is planned to help spread AI across the European economy and society. The Digital Europe programme will give better access for businesses, especially smallest ones, to AI testing and experimentation facilities in Member States. Open platforms and access to industrial data spaces for artificial intelligence will be made available across the EU in Digital Innovation Hubs.

- **Cybersecurity and trust**

  € 2.0 billion will be invested into safeguarding the EU's digital economy, society and democracies through boosting cyber defense and the EU's cybersecurity industry, financing state-of-the-art cybersecurity equipment and infrastructure as well as supporting the development of the necessary skills and knowledge.

- **Digital skills**

  € 0.7 billion will ensure that the current and future workforce will have the opportunity to acquire advanced digital skills. The Digital Innovation Hubs will carry out targeted programmes to help small and me-

dium-sized enterprises and public administrations to equip their personnel with the needed advanced skills.

- **Ensuring a wide use of digital technologies across the economy and society**

  € 1.3 billion will ensure the digital transformation of public administration and public services and their EU-wide interoperability and facilitate access to technology and knowhow for all businesses, notably SMEs.

  Digital Innovation Hubs will be 'one-stop shops' for small and medium-sized enterprises and public administrations, providing access to technological expertise and experimentation facilities, as well as advice to better assess the business case of digital transformation projects.

The Luxembourg Ministry of the Economy digital innovation strategy leverages and builds on this rich European Union digital policy and investment landscape

3 LUXEMBOURG POSITIONING IN THE GLOBAL AND EUROPEAN EMERGING DIGITAL ECONOMY

3.1 Positioning of Luxembourg

Digitisation will reshape industry and competitiveness globally. It is clear today that countries, even advanced economies, are moving at different speeds towards this digital world. The most recent "digital" competitiveness rankings of Luxembourg are presented below.

IMD World Digital Competitiveness Ranking 2018

The IMD World Digital Competitiveness ranking [7] covers the same country sample (63 economies) as the IMD World Competitiveness ranking. However, this new ranking focuses on a country's ability to adopt and explore digital technologies leading to transformation in government practices, business models, and society in general. The IMD World Digital Competitiveness ranking therefore assesses the capabilities and readiness of the economy to undertake the process of digital transformation. In its 2017 maiden report, Luxembourg was ranked 20th globally and eighth in the European Union. In the 2018 IMD Digital ranking, Luxembourg is ranked 24th globally and 10th within the European Union.

European Digital Economy and Society Index (DESI [8])

This index covers five digital dimensions: Connectivity, Human Capital/Digital skills, Use of Internet by citizens, Integration of Digital Technology by Businesses and, Digital Public Services. In 2018, Luxembourg is ranked 5th in the European Digital Economy and Society Index, therefore maintaining its 2017 position (a jump of two places from 7th in 2016).

Digital Transformation Scoreboard 2018

The Digital Transformation Scoreboard provides a European monitoring mechanism to examine key trends in digital transformation. It offered, for the first time in 2017, a unique insight into statistics and initiatives to support digital transformation, as well as reports on key industrial and technological opportunities, challenges and policy initiatives related to digital transformation.

The Digital Transformation Scoreboard uses an indicator-based monitoring of digital transformation with three key indexes; the Digital Transformation Enablers index (DTEI), the Digital Technology Integration Index (DTII) and the ICT start-up evolution index. The DTEI contains five indicators: Digital infrastructures, Investment and access to finance, Supply and demand of digital skills, E-leadership and Entrepreneurial culture. The DTII focuses on the digital transformation of businesses, whilst the ICT start-up evolution index reflects the creation of digital start-ups.

The 2018 Digital Transformation Scoreboard [9] places Luxembourg in 5th place within the EU in the Digital Transformation Enablers' Index; an improvement of one place on the 2017 scoreboard. Luxembourg "connectivity" is ranked at number 2 position with in addition, over 40% of European Union TIER IV certified data centers located in Luxembourg. On the other hand, it places Luxembourg in 22nd position with respect to the DTII (21st place in 2017). Finally, the scoreboard places Luxembourg in 9th position within the EU for the ICT Start-up Evolution Index; a significant increase from 17th position in 2017.

In addition, whilst not specifically "Digital" indicators, global flow of trade and talents are specific enablers for our future digital world. Luxembourg's rankings in these two specific areas are set out below.

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7 *https://www.imd.org/wcc/world-competitiveness-center-rankings/world-digital-competitiveness-rankings-2018/*

8 *https://ec.europa.eu/digital-single-market/en/desi*

9 *https://ec.europa.eu/growth/tools-databases/dem/monitor/scoreboard*

International Chamber of Commerce (ICC) Open Market Index 2017

The ICC's new Open Markets Index scores 75 countries on a scale of one to six on four key factors: observed trade openness, trade policy, openness to foreign direct investment and trade-enabling infrastructures. In doing so, the Index also monitors government follow through on long-standing G20 commitments to boost global trade flows. Luxembourg ranks 3rd globally in the 2017 Open Market Index and is 1st in Europe.

Global Talent Competitiveness Index (GTCI) 2018

The Global Talent Competitiveness Index (GTCI) is an annual benchmarking report that measures the ability of countries to compete for talents. The report ranks 119 countries according to their ability to grow, attract and retain talent. Luxembourg ranks 10th in the 2018 Global Talent Competitiveness Index.

Table 1: Ranking of Luxembourg in international benchmarks

Benchmark	Ranking in EU (28)	Global ranking (number of analysed economies)
IMD World Digital Competitiveness Ranking 2018	10	24 (63)
European Digital Economy and Society Index (DESI) 2018	5	--
Connectivity	2	
Use of Internet Services	4	
Human Capital	5	
Digital Technology Integration	22	
Digital public services	17	
European Digital transformation scoreboard 2018	5	--
Digital Transformation Enablers Index	6	
Digital Technology Integration	22	
ICT start-up environment	9	
International Chamber of Commerce (ICC) Open Market Index 2017	1	3 (75)
Global Talent Competitiveness Index (2018)	8	10 (119)

3.2

Strengths and challenges

None of the individual rankings discussed above, should be seen as the ultimate and definitive ranking of a country with respect to digital economic competitiveness, particularly within a place-based strengths context. However, they inform and allow for observation of trends (cf. table 1).

The IMD world digital competitiveness ranking (2018), the European Union DESI index (2018) score and, the Digital Transformation Scoreboard 2018 respectively, all position Luxembourg within the top 10 in the EU. In addition, digital innovation is intimately linked to talent availability and, it is therefore consistent that Luxembourg ranks 8th in the Global Talent Competitiveness index 2018.

A specific picture of the Luxembourg digital economy emerges from the above digital benchmarking, that of **a data-driven economy and innovation ecosystem that is competitive, with a very high quality digital infrastructure; which must address specific challenges related to the integration of digital technology within Luxembourg industry and the ramping-up of its digital ICT start-up environment**.

4 DATA-DRIVEN INNOVATION STRATEGY

4.1 Core strategy

The Ministry of the Economy's data-driven innovation strategy is based around a vision of a Luxembourg data-driven economy, that is developing and enabling the use of general-purpose digital technologies such as Artificial Intelligence (AI) coupled with Internet of Things (IoT) smart components, systems and networks, HPC and Big Data analytics to drive future growth.

The overall goal of this innovation strategy is to propose a vision and path forward for Luxembourg, to put in place the digital innovation policies and assets necessary to both support the emergence of a Luxembourg data economy and start-up ecosystem and accelerate the digitalization-enabled transformation of its existing industry across the key strategic sectors of the Economy.

The Luxembourg data-driven innovation strategy is built around the following three key pillars.

4.1.1 Boosting and assuring digital infrastructure capacity

In a data-driven economy, data is quite simply the key resource and enabler of innovation, allowing the customisation of products and services that is increasingly essential to respond to customer demand. However, data relies on digital infrastructure including connectivity, high performance computing, cybersecurity and secure data storage. Boosting and assuring a new world-class Luxembourg infrastructure capacity for this new global digital age is the first thrust of the data-driven innovation strategy.

- In the past months, the measures taken by the Luxembourg Ministry of the Economy to ensure world-class competitive digital infrastructure and platforms for product and services innovation have included **initiatives on High Performance Computing (HPC) and Big Data**, the new building blocks of digital infrastructure competitiveness. These initiatives have resulted in Luxembourg being designated as the host location for the European Commission Joint Undertaking EuroHPC agency. As a core element of its infrastructure innovation pillar, Luxembourg is firmly committed to acquiring a significant HPC capability and to working closely with the European Commission to support the development of a European wide HPC ecosystem.

- In parallel, with this digital infrastructure roll-out, and reflecting the increasing consumption of energy in ICT data processing applications [10], the Ministry of the Economy will work with all actors to **ensure innovative technological approaches and solutions to energy sustainability**, to minimise as best possible, energy consumption in the future sustainable data-driven economy.

4.1.2 Experimenting, innovating and up-take of new advanced digital technologies into industry

The convergence of a transformative set of general-purpose digital technologies (AI, HPC, Internet of Things) has the potential to open up significant new sources of value and growth for industry and will allow Luxembourg to maintain its competitive advantage. With the new Artificial Intelligence strategic vision for Luxembourg particular focus is on AI, which could strongly contribute to boost productivity and thus accelerate the growth of the economy across all key sectors [11]. One key element in the context of this pillar, will be positioning Luxembourg as a living lab for AI.

However, it is recognized that Luxembourg industry needs support and encouragement to experiment, innovate with, and up-take these advanced digital technologies, to accelerate their integration and up-take into products

[10] *Today approximately 10% of the planet's energy is consumed by the energy requirements of the cloud. In the European Union, data centers account for approximately 1.8% of the Union's energy consumption.*

[11] *The Ministry of the Economy is deeply engaged in contributing to the European Member States and European Commission Artificial Intelligence Coordinated Plan, published on 7 December 2018 and which will last until the end of the Multiannual Financial Framework in 2027.*

and services across all industry sectors; this is the second axis of the data-driven economic strategy.

- The Ministry of the Economy is currently **supporting digitising industry experimentation, support platforms, testbeds** (trial and error to market penetration) **and Regulatory Sandboxes** both at national and European level. In particular, the Ministry of the Economy will support access to the European Commission initiated AI-on demand platform.

- Luxembourg will **establish a Digital Innovation Hub (L-DIH)** to accelerate uptake of general-purpose digital technologies and digital best practicies. The launch of this hub, scheduled for mid 2019, will be a joint initiative of the Ministry of the Economy, FEDIL, the Chamber of Commerce, Luxinnovation [12] and key public research partners in the digital domain (including the LIST and the University of Luxembourg). The L-DIH secretariat will be established and resourced within Luxinnovation. The Luxembourg-DIH will also, within the framework of the Member States' AI Coordinated Plan, identify and connect with AI-related Digital Innovation Hubs and European Commission supported AI-related testing and experimentation facilities, to support the uptake of AI into Luxembourg SMEs and thus provide the framework for Industry 4.0 in Luxembourg.

4.1.3

Ensure a strong regulatory, intellectual property, investment and financing environment

The third thrust of the data-driven innovation strategy is to ensure a world-class innovative regulation and intellectual property environment coupled with strong investment and financing tools in Luxembourg.

- Policy actions will address "data economy" regulations that keep pace with both the transforming rules of competition and new emerging digital opportunities. In particular, to ensure an innovative regulatory environment in the area of **cybersecurity**, in order to enable trusted data-driven services. These will leverage novative Regulatory Sandboxes.

- A second key element for policy consideration across all sectors will be the **increasing importance of intellectual property rights (IPR) in the digital economy**. In Luxembourg, the overall contribution of IPR-intensive industries to the share of GDP is above 45%. The fastest growth rates in filing of new intellectual property is observed in enabling digital technologies such as 3D manufacturing and artificial intelligence, essential to key sectors of the Luxembourg economy. It is expected that by 2020, over 50% of all patent applications filed at the EPO [13] will claim a digital implemented invention.

- Finally best-in-class **dedicated digital investment funds and financing mechanisms** will be established on the one hand through seed and venture capital funds and public private research and innovation partnerships and on the other hand through support programmes for innovation and digitalization, R&D incentives and special support for start-ups will boost digital innovation.

This data-driven innovation strategy will be actively supported by Luxembourg's innovation agency, Luxinnovation.

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[12] *The mission of Luxinnovation is:*
- *To encourage and support companies to innovate and grow in a smart manner and to prepare themselves for the challenges of the future, which brings new and potentially disruptive technologies*
- *To facilitate collaboration between Luxembourg public research and companies*
- *To ensure that Luxembourg continues to attract international investment, companies and skills that are a perfect fit for the country*

[13] *European Patent Office; www.epo.org*

4.2

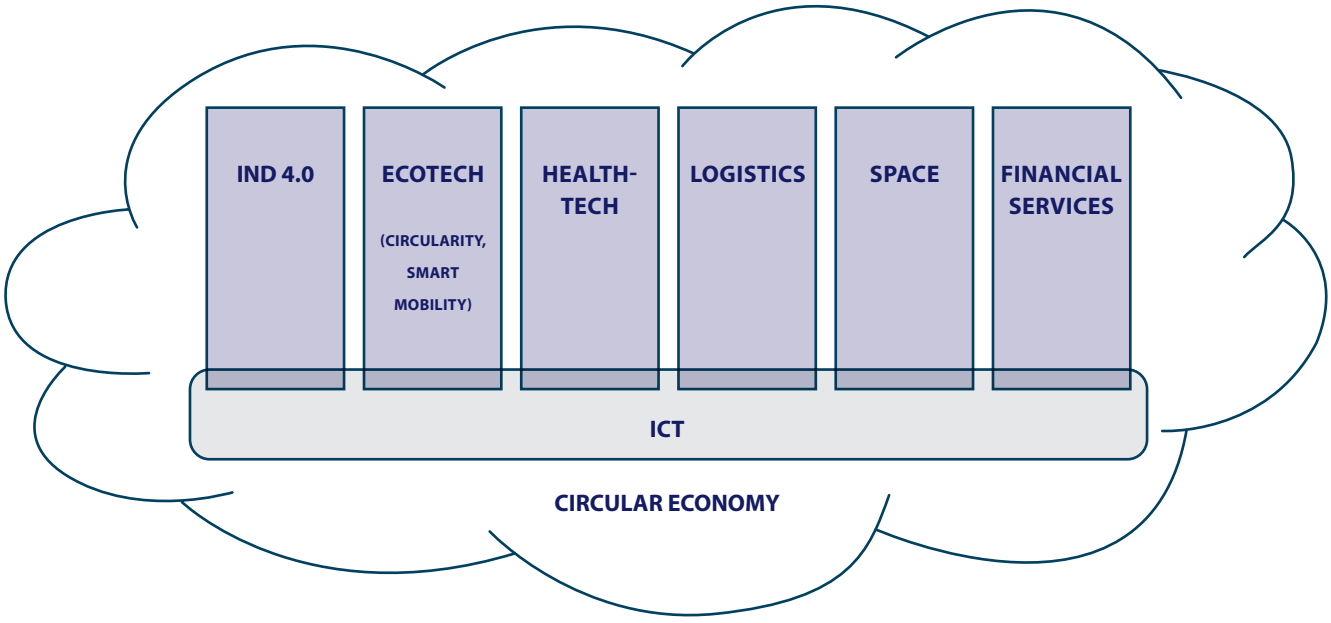
Focus on strategic sectors

The Luxembourg coalition agreement 2018-2023 [14] established in 2018 sets out an active policy in the face of rapid global change to develop and diversify alongside the financial sector the fabric of the economy according to a "multi-specialization" strategy. It focuses diversification efforts on a small number of specific sectors to achieve critical mass and impact.

The government programme identified seven priority sectors [15] in the domain of economy and communications: Information and Communication Technologies (ICT), Manufacturing Industry, Eco-technologies (including Circularity and Smart Mobility), Health technology, Logistics, Space and Financial Services (from the data economy perspective) as shown below (cf. schematic 1).

The Ministry of the Economy will focus on these sectors and the strategy will be implimented in coordination with all concerned ministries, mainly the Ministry of Energy and Spatial Planning, the Ministry of Mobility and Public Works, the Ministry for Digitalisation, the Ministry of State, as well as the Ministry of Higher Education and Research and the Ministry of Environment, Climate and Sustainable Development.

Schematic 1: Data-driven innovation strategy priority sectors



[14] *Accord de coalition 2018-2023, https://gouvernement.lu/fr/publications/accord-coalition/2018-2023.html*

[15] *Six of these priority sectors are detailed in the 2017 Luxembourg "Research and Innovation Smart Specialisation Strategy (RIS3), https://gouvernement.lu/fr/publications.html*

5 SECTOR SPECIFIC INNOVATION PLANS AND POLICIES FOR 2019-2023

5.1

Information and Communication technologies

5.1.1

Context and Vision

With 4% of GDP, the information and communication technologies (ICT) sector in Europe represents an important share of the economy employing more than 6 million people. The value added of this sector in the EU (production of digital goods), spanning from components to software products is above € 580 billion and represents close to 10 % of the added value of industrial activity overall.

More importantly, the ICT sector is the backbone of the Digital Economy today. In fact, one definition of the new digital economy is "The digital economy is the worldwide network of economic activities, commercial transactions and professional interactions that are enabled by information and communication technologies" [16].

Digital information and communication technologies and platforms will boost productivity across all sectors and industries of modern economies, and is happening at a scale and speed that bring immense opportunities for innovation, productivity, growth and jobs.

5.1.2

Luxembourg, a digital leader ready to face new challenges

Since 2000, Luxembourg has identified the importance of ICT for the successful diversification of the country's economy. Major infrastructure investments have developed extensive broadband networks ensuring international connectivity and state of the art high-end data-centres have been built. In parallel, interdisciplinary public research centres such as SnT [17] and LCSB [18], heavily relying on ICT capabilities and expertise, have been created by

16 *https://searchcio.techtarget.com/definition/digital-economy*

17 *Interdisciplinary Centre for Security, Reliability and Trust; https://wwwfr.uni.lu/snt*

18 *Luxembourg Centre for Systems Biomedicine; https://wwwfr.uni.lu/lcsb*

the University of Luxembourg to foster academic excellence in this field. These initiatives together with a growing start-up ecosystem and a strong economic fabric of major ICT industry players, RTL Group, SES, Amazon, PayPal, eBay, Rakuten and Vodafone ensure that Luxembourg stand's on solid foundations to face future ICT enabled opportunities and challenges.

In a new data centric digital interconnected future, data will be the common asset driving growth and efficiency across all sectors identified as priorities for the national economy. This entails substantial changes for Luxembourg, as value continues to shift from tangible to intangible assets the importance of intellectual property rights, cybersecurity, digital identity, cross-border data exchanges, HPC and new data centric technologies become essential to maintain the future competitiveness of Luxembourg based companies.

5.1.3

Building a trusted data-driven economy 2019-2023

Luxembourg will strive to become the most trusted data-driven economy within the European Union by 2023. Luxembourg will be the location of choice for international groups to centralize proprietary data and create value from it. Luxembourg will be at the forefront of data innovation driven by start-ups closely collaborating with corporate open innovation hubs or deploying testbed activities. To achieve this vision over the coming years, the Ministry of the Economy will implement the following policy and investment measures:

1. Build a trusted business environment for data centric business to develop internationally

Create a strong legal framework for ownership, licensing, exchange and usage of data assets. This should be coupled with the development of an innovative regulatory environment and internationally recognized certification schemes for enabling activities and technologies (e.g. digital identity and attribute management, data brokerage, data fiduciary services, data escrow, data clearing, KYC [19], etc.) in order to allow the deployment of trusted and secure data-driven services.

2. Foster data innovation

Create specific RDI support programs and investment vehicles tailored to data-driven businesses wanting to adopt general-purpose digital technologies (e.g. Blockchain, Artificial Intelligence, Cryptography, Big Data Analytics, HPC). These new tools will have the triple objective to help local companies find talented employees, enable multinational groups to locate their data hubs in Luxembourg and attract high-quality innovative data focused start-ups.

3. Establish Luxembourg as a testbed location for data businesses

Support and facilitate the deployment of data related testbeds (e.g. HPC testbeds within the EuroHPC JU programme) in Luxembourg. Foster the participation to testbed projects of local and international companies through the creation of specific financing tools and facilitate the participation of public entities by adapting public tender procedures.

4. PPP projects as catalysts to the adoption of the data-driven economy

Strengthen the operations of the Cybersecurity Competence Centre [20] (C3) to create Luxembourg's leading collaboration platform for threat intelligence and training in cybersecurity. Intensify its collaboration with the banking and insurance sectors. Create a national HPC and Big Data Competence Centre to deliver computing and Big Data services to the Luxembourg's economy and contribute to the country's cyber defence implementation strategy. Identify and implement new, high potential, PPP projects which are necessary to accelerate the adoption of a data-driven economy in Luxembourg.

5. Acquiring data skills

Build in Luxembourg a pool of data advisory expertise.

[19] *Know Your Costumer*

[20] *The Cybersecurity Competence Center (C3), Ministry of Economy, https://c-3.lu/*

Available policy levers (e.g. immigration, education, taxation) should be explored at personal and corporate level to attract foreign data experts. The fields of Data Science (data analytics, statistics, algorithms, simulations, etc.) and data regulation (GDPR [21], eIDAS [22], NIS [23], etc.) should be initially targeted. This initiative should be closely coordinated with the talent attraction strategy due to be elaborated by the Trade and Investment Steering Committee [24].

6. Promoting Luxembourg's data-driven economy internationally

Create and deploy a digital communication strategy to position Luxembourg as the ideal place to develop a data business and grow it internationally. Such an initiative should fully leverage the potential of digital communication channels and new technologies to target specifically identified data business segments of high interest such as data brokers or digital ID providers. This initiative should be integrated in Luxembourg's economic promotion strategy, driven by Luxinnovation, and include the network of existing LTIOs [25].

5.2

Industry 4.0

5.2.1

Context and vision

Europe's industry is strong and has retained a leading position in many sectors in global markets, especially in high value added, low carbon and sophisticated products and services. Industry accounts for two thirds of the EU's exports and provides jobs for 32 million people [26]. This position has been built on a large Single Market with 500 million consumers, strong value chains, a skilled and talented workforce and a world-class science base. The market shares of EU exports are gradually increasing for goods and stable for services. Industry gross value added for the EU27 has increased by 6.4% between 2009 and 2016.

21 *EU General Data Protection Regulation, https://www.eugdpr.org/*

22 *The Regulation (EU) N°910/2014 on electronic identification and trust services for electronic transactions in the internal market (eIDAS Regulation) adopted on 23 July 2014 provides a predictable regulatory environment to enable secure and seamless electronic interactions between businesses, citizens and public authorities, https://ec.europa.eu/digital-single-market/en/trust-services-and-eid*

23 *EU Directive on security of network and information systems, https://www.itgovernance.co.uk/nis-directive*

24 *http://luxembourg.public.lu/fr/actualites/2016/06/01-LFB/01-structure-organes.pdf*

25 *Luxembourg Trade and Investment Office; https://www.tradeandinvest.lu/*

26 *President Jean-Claude Juncker, State of the Union 2017 - Industrial Policy Strategy: Investing in a smart, innovative and sustainable industry.*

However, major efforts are needed to adjust to global challenges and reap the vast opportunities of the new industrial age. The hallmarks of this new Industry 4.0 are the accelerated pace of economic, societal and environmental transformations as well as digital technological breakthroughs. Automation, enabled by information technologies, is transforming traditional manufacturing processes and the nature of work. Industry is increasingly integrated in global value chains with strong service components. Emerging business models disrupt traditional markets. Innovation itself and value creation are changing in profound ways. This is blurring the distinction between manufacturing and services. Data are becoming the new competitive factor in our connected world.

The convergence of a number of technologies is driving the digital enabled Industry 4.0, notably IoT, Big Data and cloud, robotics and artificial-intelligence as well as 3D printing. They enable industry to respond to major aspirations of today's customers, such as personalisation, higher safety and comfort as well as energy- and resource efficiency [27].

To be able to reap the full benefits of digital technologies, Europe needs both a highly innovative digital sector and an upgrade of the digital innovation capacity of all industries.

The Industry 4.0 opportunity is enormous; recent studies estimate that digitization of products and services will add more than € 110 billion of revenue for industry per year in Europe in the next five years [28]. In Germany alone, further digitization of industry is expected to bring up to 8% of productivity growth over ten years and a revenue growth of about € 30 billion per year representing close to 1% of German GDP. It will also lead to a 6% increase in employment. Close to a third of the growth of the overall industrial output in Europe is already due to the uptake of digital technologies.

5.2.2

Luxembourg today and assets for Industry 4.0

The share of EU GDP represented by industry has steadily declined from 23.3% of EU GDP in 1995, to just over 19% in 2015 [29]. The share of industry in EU employment fell from 20.9% in 1995 to 15.4% in 2015. This has been mirrored in Luxembourg, where, in spite of a long industrial tradition, the share of Luxembourg industry in the creation of national added value has continually decreased, of the order of 7.8 percentage points over the past twenty years between 1995 and 2015. In 2016, Luxembourg's industrial manufacturing sector employed 32,200 people or 7.7% of the total national employment. Industrial production accounted for € 9.67 billion, representing 5.3% of the total value added.

Industry 4.0 represents a potential game changer with tremendous opportunity to reinvigorate the Luxembourg industrial sector. It may allow significant productivity gains and enable Luxembourg to attract small sized, highly flexible batch manufacturing capacity.

Luxembourg industry has considerable advantages to respond to the competitive need for digitization of its industry fabric and create a resilient Industry 4.0 sector. The willingness to innovate within the Luxembourg industry ecosystem is much greater than in other sectors of the economy. In 2013, 63% of private R&D expenditure came from the industrial sector. Production processes are already largely automated. The country has one of the highest performing digital broadband networks in the European Union and the government is investing in new HPC and Big Data infrastructures. ICT services are particularly well developed and public research centres have internationally recognized expertise in data and information security. The vision to embrace high technology manu-

[27] *Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions; Digitising European Industry Reaping the full benefits of a Digital Single Market*

[28] *PwC, opportunities and Challenges of the industrial internet (2015), and Boston Consulting Group: the future of productivity and growth in manufacturing industries (2015)*

[29] *Eurostat, Weight of economic activities, 27 October 2016*

facturing in growth markets enabled by industry 4.0 technologies could thus be reflected in the following statement: **"Become a leader in data-driven, sustainable high value manufacturing solutions"**.

5.2.3

Implications for industrial policy

The objective over the coming five years is to accelerate the transition from a traditional industrial manufacturing sector to a digital technology enabled data-driven Industry 4.0 ecosystem in Luxembourg.

The Ministry of Economy action plan below includes several measures to address the current challenges that Luxembourg faces in the digitalization of its industry.

1. Accelerate digitalization initiatives in existing companies

Develop a Smart-Industry Action Plan together with industry representatives to accelerate the penetration rate of digital transformation initiatives, in particular amongst SMEs. This action plan must promote the broad deployment of Industry 4.0 technologies with a special focus on:

- Diversifying traditional manufacturers into new growth markets of high technology manufacturing;
- Increasing industrial excellence and level of service to differentiate as high value manufacturers;
- Improving production efficiency to maintain profits in shrinking markets.

Potential policy actions to support existing companies could include the following:

- Strengthen existing initiatives with the objective to help SMEs to accelerate their digital transformation;
- Further support the programme Fit4Digital [30] in order to guide and help SMEs to take a step forward to digital transformation actions;
- Co-fund research and development projects specifically in the areas of Industry 4.0, Internet of Things and cyber physical systems in SMEs.

2. Attract foreign companies

Prospection efforts should be designed to attract not only companies with appropriate business profiles, but also those that provide the enabling technologies for Industry 4.0.

3. Creation of high value added manufacturers

Start-up specific policy levers to promote the creation of high value manufacturers may include:

- Strengthening existing initiatives:
  A call in the programme Fit4Start dedicated specifically to attract applications by high value manufacturers.

- New initiatives:

  Granting start-ups corresponding to the profile above, a preferred access limited in time to HPC infrastructure and secure cloud-based services;

  Dedicate parts of the Luxembourg Future Fund to stimulate venture investors and start-ups to place or expand smart production, industrial services, research, development and testing in Luxembourg;

4. Support for high-risk proof of concept Industry 4.0 programme

Manufacturing industry together with research organisations can apply for funding for short-term high-risk projects.

Initiate regular calls for co-founded R&D projects focusing on testing or demonstrating new technologies and methods in realistic production environments.

[30] *Fit4Digital; www.luxinnovation.lu/innovate-in-luxembourg/performance-programmes/fit-4-digital/*

5. **Investment incentives for Industry 4.0 related expenditure**

Make an assessment on introducing tax measures to foster private investments in innovative SMEs (and start-ups).

6. **Develop a Luxembourg-based Digital Innovation Hub (LDIH)** with appropriate services to help accelerate the digital transformation of the Luxembourg industry

Via the Luxembourg DIH, develop partnerships with targeted European industrial DIH's.

5.3

Eco-technologies

The eco-technology sector within the Department of new technologies of the Ministry of the Economy comprises two focus areas: Circular Economy and Smart mobility, wich are coordinated with the concerned ministries, notably the Ministry of Energy and Spatial Planning and the Ministry of Mobility and Public Works.

5.3.1

Circular Economy

5.3.1.1
Context and vision

Extending the use cycle, increasing utilisation and cascading and looping the asset are the three main circular value drivers. Circular economy is all about using resources in the most efficient, non-destructive way by optimis-

ing the design and use phase and keeping them in eternal technical or biological cycles, leading to the elimination of the concept of waste itself. To manage resources it is crucial to manage the data about materials and the components and products they were built into. Location, composition, activity, performance, wear and maintenance requirements are a few of the relevant data sets.

Key elements of the circular economy are performance-based business models in which the supplier keeps ownership of a product and provides a service. Ideally, the customer buys a performance and leaves it to the supplier to choose the most efficient means to provide it. This approach is a strong incentive for a manufacturer to develop efficient, long-lasting products that can be reused, repaired, remanufactured or recycled completely. The manufacturer or integrator remains at least partially responsible for his product all throughout the use phase hence profiting directly from its efficiency and suffering from its negative impacts.

The interests of the customer and the supplier are aligned, both looking for the most efficient solution that creates true value. Even though these servicing business models can lead to higher profitability, improve a company's position in a value chain, bind customers, enhance the value of its offerings and improve its innovation potential, the market share of these business models is still quite low. Researchers claim that they are a win-win-win model for people, profit and the planet but their implementation remains a challenge for linear companies evolving in linear systems. Some of the hurdles are stemming from internal and external change management, heterogeneity in the customers' requests, complexity of new contractual agreements, insurance issues, accounting, logistics, total cost of ownership estimations, financing and cash flow management as well as developing the most promising value proposition.

However, the pressure on current business models is growing as environmental regulations become stricter, producer responsibility is increasing, raw materials become scarce and competition from low cost countries is raising. Moreover, the European Commission and national governments are pushing for the implementation of a circular economy and first competitors have developed performance based offers.

New data-driven technologies grant access to real-time information and generate low cost efficient data management solutions, which in combination with automation are key enablers to develop the performance economy whose time seems to have come. Data-driven innovations allow tracking of products, components and materials as well as to assess the current stock and develop concepts like "buildings as material banks" and the "material passport".

Real-time performance monitoring and automatic invoicing will be possible as well as drastic increase in resource productivity by virtualisation of all but the core physical function of equipment.

The sharing economy increases utilisation of an asset and IoT allows organising the logistics to close the loop and link demand and offer for secondary products, materials and components as well as valuate their current and future market price. The acquired data will help to understand the financial fundamentals and develop new financial and accounting services as well as taxation schemes and value propositions.

In order to be effective, the data needs to be accessible all along the integrated value chain. Transparency and trust between the stakeholders of the chain are essential. Some of the information is critical and IP, ownership, data security and safety are of high importance. Honest brokers safeguarding all relevant information while only providing each stakeholder the required information are important enablers.

5.3.1.2
Circular economy in Luxembourg today

The performance economy is recognized as an innovation driver with an important disruptive potential which fits Luxembourg's efforts to diversify its economy that is to become more and more knowledge and innovation driven. Moreover, the Grand Duchy is commercially neutral with a service and data-driven open economy and well positioned to become an honest broker for Europe's circular economy and develop data-driven performance based services. The circular economy is already present in

most sectors in Luxembourg and although it is only at the beginning of its development, it constitutes already an interesting test market. The following initiatives are part of the key developments to-date:

- Holistic strategic study on circular economy in Luxembourg done in 2014 including the creation of the "Strategic Group for Circular Economy" and related working groups to coordinate all circular activities. In 2016, the circular economy was included as a horizontal topic to be addressed by all six pillars of "The Third Industrial Revolution".

- The Fit4Circularity support scheme providing financial support to innovative companies.

- Major circular events like "Financing the Circular Economy" in 2015 at the EIB [31] and the "Circular Economy Hot Spot" in 2017 as well as the development of training and education tools.

- Circular criteria integrated into the "pacte climat" to stimulate municipalities to become circular in collaboration with the municipality of Wiltz, the pilot town for circularity.

- The Wood and EcoInnovation clusters to close the loop and establish value chains for local materials including timber.

- Large pilot projects in urban development such as: "Kirchberg", "Wunnen matt der Woltz", "Automotive Campus" and "Néi Schmelz", including construction and manufacturing companies.

  In order to implement performance based business models, companies need to drive the transition internally but also require an ecosystem that supports their efforts. Luxembourg's integrated public and private stakeholders can build this ecosystem and support the transition on many levels. Thus Luxembourg will make the circular economy attractive for stakeholders through the continuous development of pilot projects that allow dedicated working groups to learn and to co-create a circular ecosystem.

5.3.1.3
Key policy initiatives and investment actions during the forthcoming 5 years

1. Circular test market

In order to provide a test outlet for circular solutions and products, the domestic test market should be developed further. First important achievements have been reached by including circular economy principles in the masterplans of large urban development projects and by integrating the circular economy into the municipalities' climate pact encouraging circular procurement. Additional work is required to develop best practices, guidelines and potential regulatory modifications in the field of public procurement and in particular in the data-driven performance economy.

In the construction sector, based on the "Building Information Modeling" (BIM) initiative, material passports are to be developed including all relevant information to turn buildings into material banks. On the long term, a nationwide rollout can lead to a databank of all building materials on the territory of the Grand Duchy and their corresponding value.

2. Data Hub

Current initiatives to keep products, components or materials in the loop as long as possible are often limited to down cycling the materials into low value products and to very few numbers of possible cycles. In order to maintain and remanufacture products, to reuse components and to upcycle materials and retain or increase their values, it is crucial to know their design, functionality and composition in detail. Data on products and components is rarely available today and lacks precision for materials that are grouped in generic categories as for example "plastics". Automated processes are needed as well as trusted data brokers granting access to information if required while protecting trade secrets and other confidential data. The Ministry of the Economy in collaboration with the involved actors is positioning Luxembourg as a data hub for the circular economy to provide data, knowledge and services to circular stakeholders and complete integrated value chains.

[31] *European Investment Bank; http://www.eib.org/en/index.htm*

3. Finance

Financing the transition costs to circular business models is a challenge for most companies. Under the lead of the Ministry of Finance, Luxembourg shall become a circular finance hub attracting dedicated financial vehicles to a competitive environment. Value chain financing or material funds are two of the leads to be investigated. The financial, regulatory, fiscal and accounting systems need to be adapted to the circular economy.

4. Performance economy eco-system

Companies face important challenges when switching from linear to circular business models, in particular when implementing a performance based functional economy. Besides the internal change management, they need an ecosystem supporting their developments. By federating the relevant stakeholders, Luxembourg can create this attractive ecosystem and develop a new specific sector by addressing issues and developing new services related to accounting, financing, insurance, liability, tax, contracting, testing, regulation, standards, value propositions and qualified intermediaries such as consultants and entrepreneurs. The hotel sector is an example for which the Ministry of the Economy investigates how local SMEs can offer performance and product as a service-based model for hotel interiors.

5.3.2

Smart Mobility

5.3.2.1
Context and vision

Data related to "Smart Mobility" activities is rapidly evolving into a key topic on the agenda of the auto, tech and telecom industries, service providers and public authorities. A recent report on Car Data[32] forecast that "[…] the expected growth of the value pool from car data and shared mobility could add up to more than USD 1.5 trillion by 2030". Conservative estimates from IHS Automotive state the average connected car will produce up to 30 terabytes (TB) of data each day among others for safety systems, infotainment, location-based services,

[32] *Car data: paving the way to value-creating mobility. Perspectives on a new automotive business model; McKinsey & Company. Advanced Industries (March 2016)*

dealer services, quality and reliability applications, as well as tailored customer experience. According to Intel, future autonomous vehicle systems will add another 4 TB per 1 hour of driving per day.

The associated data value chain, ranging from data producer(s) to data consumer(s), includes contributions from automotive suppliers, OEMs, hardware providers, technology vendors, network operators, data platforms and brokers, service and application providers, system integrators, financial services, mobility providers, all the way to the end users. An efficient and profitable connected car ecosystem will require the collaboration between these varieties of stakeholders within a dedicated regulatory framework favourable to innovation and new business models.

Building on its prior investments in a first-class digital infrastructure, and leveraging current flagship initiatives (HPC and Big Data applications, Cybersecurity Competence Centre (C3), etc.), Luxembourg is well positioned to become a key actor of the new data economy arising from the digitalization of mobility.

In particular, entities in Luxembourg could diversify their client portfolios and tailor their offerings for the specific needs of the connected vehicle ecosystem. Those include for example data optimisation services, data anonymization services, data aggregation services, data brokerage (contextualisation), (live) data analytics as well as prediction and forecasting.

In a subsequent step, those activities could be bundled around a Connected Car Data Platform, which converts raw data into essential information, thus paving the way towards valuable knowledge that will ultimately lead to actionable insights with high added value. Application examples include advanced simulation capabilities required to support adaptive machine learning algorithms for Connected and Autonomous Vehicles (CAVs) or the live prediction of mobility patterns for the intelligent management of CAV fleets using multiple input sources.

5.3.2.2
Smart mobility in Luxembourg today

The topic of data stemming from the mobility sector is still in its infancy in Europe with most relevant activities taking place either in dedicated large-scale projects [33] or through individual initiatives from the Industry [34]. Luxembourg has detected this window of opportunity and is positioning itself through tangible measures:

- Joining the cross-border testbed initiative on cooperative, connected and automated driving (CCAD) with Germany and France and introduce a dedicated thematic on "Data access and use".

- Partaking in the EU public-private Data Task Force [35] and attract the pilot project for a connected vehicle architecture foreseen in its mandate on the DE-FR-LU cross-border testbed.

- Representing the interests of Luxembourg in the EU C-ITS [36] Committee on all activities related to the follow-up of the action plan automated and connected driving and the implementation of Cooperative Intelligent Transport Systems (C-ITS).

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[33] *Nordic Way, Autopilot, SCOOP@F, Enable-S3*

[34] *CLEPA "Caruso", FEBIAC/IBM/PSA "Connected Vehicles " programme, DAIMLER/AUDI/BMW via Here,*

[35] *"Action plan automated and connected driving" – 2nd High Level Structural Dialogue (15/09/2017)*

- The government has proactively supported the positioning of Luxembourg public and private actors in competitive H2020 consortia on cooperative, connected and automated mobility.

- The Ministry of the Economy is already in close contact with the CNPD[37] (Commission National pour la Protection des Données) in view of drafting a dedicated recommendation with respect to data originating from connected vehicles or other telematics solutions in the area of smart mobility.

- Finally, a sub-working group has been initiated to regroup public research activities on Cooperative Connected Autonomous Mobility (CCAM) carried out by uni.lu, LIST and LISER[38] under a common umbrella in order to streamline their efforts and achieve synergies on the topics covered.

5.3.2.3
Key policy initiatives and investment actions during the forthcoming five years

In order to **position Luxembourg as a preferred hub in the Connected Vehicle Data Economy**, the following additional steps should be considered:

1. Encourage local actors with key competencies to **diversify their activities** towards the future needs of the CCAM applications.

2. **Attract foreign companies** with complementary skillsets as part of the overall prospection strategy.

3. Continue to **build strategic alliances and partnership models** with key stakeholders in the field.

4. **Define a favourable legal framework** for CCAM Data that clearly determines the purposes and means of processing in particular applied to the handling of personal data (incl. passenger health). In that context, a focus should be set on creating business-oriented data governance models safeguarding fair competition and promoting an open attitude towards innovation.

5. **Establish regulatory requirements** to share data in a safe and secure manner to government and public authorities amongst others for applications related to road safety, traffic efficiency and usage-based taxation.

6. **Adapt regulations on vehicle insurance**, including the definition of responsibility for actions of AVs.

7. **Initiate a visionary and ambitious use case** to federate the actors of the smart mobility ecosystem and converge their competences towards a flagship project that makes extensive use of the CCAM data.

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[36] *Cooperative Intelligent Transport Systems (C-ITS) will allow road users and traffic managers to share information and use it to coordinate their actions. This cooperative element – enabled by digital connectivity between vehicles and between vehicles and transport infrastructure – is expected to significantly improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to the traffic situation. https://ec.europa.eu/transport/themes/its/c-its_en*

[37] *https://cnpd.public.lu/en.html*

[38] *The Luxembourg Institute of Socio-Economic Research (LISER) is an independent institute for social and economic research addressing policy relevant issues based on state-of-the-art scientific methodology.*

5.4

Health technology

5.4.1

Context and Vision

Digital Health as a leverage to accelerate the transition from a research-driven to a business-driven innovative biomedical ecosystem in Luxembourg.

Today, all industries must integrate the pace of digitalization [39]. This is also true for the healthcare sector where the use of ICT in health-related products, services and processes is defined as digital health. The global digital health industry is classified into four main technology segments, i.e. telemedicine, mobile health (or mHealth), Big Data analytics and digital health systems (or eHealth). The global digital health market is foreseen to reach USD 379.3 billion by 2024 [40]. Dominated by North America, the digital health market is expected to expand in Europe and register the highest growth in Asia Pacific, amongst which in Japan.

Big impact in terms of economic growth are expected from digital health because digital products and solutions are at the centre of an emerging transformation of the biotech, pharma, and medical device industries which serve the healthcare systems, as well as of the medical & clinical practices themselves. The drivers behind this transformation are: (1) the increasing use of Big Data analytics in personalised medicine, (2) the stronger interest for value-based medicine and cloud-based analytics, (3) the increasing adoption of patient registries, (4) the growing desire of consumers to use wireless wearable monitoring devices and (5) the stronger influence of digital media in healthcare [41].

As defined by European Commission (EC), *"personalised medicine refers to a medical model using characterisation*

[39] *Healthcare's digital future | McKinsey & Company. Available at: http://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/healthcares-digital-future. (Accessed: 22th February 2018)*

[40] *Digital Health Market size to exceed $379bn by 2024. Available at: https://www.gminsights.com/pressrelease/digital-health-market. (Accessed 22th February 2018)*

[41] *Digital Health Market size to exceed $379bn by 2024. Available at: https://www.gminsights.com/pressrelease/digital-health-market. (Accessed 22th February 2018)*

of individuals' phenotypes and genotypes (e.g. molecular profiling, medical imaging, lifestyle data) for tailoring the right therapeutic strategy for the right person at the right time, and/or to determine the predisposition to disease and/or to deliver timely and targeted prevention." [42] Personalised medicine relies on biomedical data of increasing volume (terabytes per patient), variety (clinical, eHS, "omics", cytometry, imaging, pharmacology, pharmacovigilance, ...), and velocity (real time telemetric monitoring of patients, social media feeds, ...) which provide tremendous opportunities for health research, development and innovation through Big Data analytics [43].

Digital health has been put forward by the EC as an essential solution to address the demographic challenges associated with the ageing of the European population. Digital health, when applied effectively and efficiently, is expected to enable high quality of life, well-being and personalized care to all citizens while containing upward pressure on public health expenditures in the long run, contributing therefore to the sustainability of national healthcare systems [44]. Personalised medicine and digital health have therefore become inseparable.

5.4.2

Digital Health as a Game Changer for Luxembourg

Through its "Science & Health Technologies Action Plan", Luxembourg made the strategic choice, in 2008, to build on the considerable potential offered by biotechnologies and biomedicine in terms of industrial development to diversify its economy. Significant investments were made over the last ten years in biomedical public research to set up the research foundations needed for the implementation of personalised medicine in Luxembourg. They have allowed the development of a critical mass of internationally recognized scientific expertise and capability in biological and health data analytics for research and/or clinical purposes able to support the transition of clinical practices towards personalised medicine locally, as illustrated by the National Center of Excellence in Research on Parkinson's Disease (NCER-PD) [45].

While positive, the macroeconomic impact of this initiative in terms of substance and value generated on the Luxembourg territory (e.g. company creation, investment, turnover, job creation) is slow and gradual. As such, the Health Technology sector is highly fragmented and still lacks maturity. Its 131 actors (private medical analysis laboratories and TPE/SMEs) contributing altogether for 0.38% of the national economy in terms of added value [46]. In the last years, the ecosystem has witnessed the continuous emergence of 31 digital health start-ups and companies and the quick adoption of digital technologies in private laboratories. This bottom-up trend reflects the attractiveness of our eco-system towards digital health companies. It is now time to build on it and capture the potential of digital health technologies to accelerate the transition from a research-driven to a business-driven innovative biomedical ecosystem in Luxembourg.

Building on biomedical research efforts and making the most of existing national ICT strengths (infrastructures, cybersecurity, relocation of DG Connect, IPCEI-HPC, digital seed fund) the ultimate goal is to offer digital health companies the conditions they need to innovate, grow and support the emergence of citizen-driven health and well-being and patient-centred healthcare services in Luxembourg. This would promote the country as an attractive territory for digital health companies and contribute to a smart and sustainable economy and society. This digital health orientation is fully aligned with the objectives of the Digital Lëtzebuerg Strategy and the Third Industrial Revolution Strategy which recognise ICT as a key driver for competitiveness and sustainability.

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42 *Council conclusions on personalised medicine for patients (2015/C 421/03)*

43 *Terms of reference of the Strategic Governing Group on Digital Health & Patient-Centric Evidence Generation (2018-2024)- IMI2-GB-DEC-2018-02 Annex*

44 *Commission, E. Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions. eHealth Action Plan 2012-2020 -Innovative healthcare for the 21st century.)*

45 *More information: http://parkinson.lu/index.php/en/en-why-research/what-is-ncer-pd*

46 *Available at: https://www.luxinnovation.lu/event/health-technologies-luxembourg/*

5.4.3

Making Luxembourg an attractive ecosystem for digital health companies

With the ultimate goal to **accelerate the transition from a public research-driven to a business-driven innovative biomedical ecosystem in Luxembourg**, the plan is to build in the next five years (2019-2023) an attractive digital health ecosystem able to sustainably offer digital health companies the conditions they need to innovate, grow and support the emergence of citizen-driven health and well-being and patient-centred healthcare services.

The Ministry of the Economy action plan below includes 6 key new measures proposed to address the current challenges to further enhance attractiveness of Luxembourg for digital health companies:

1. Create an **interministerial task force** to develop an innovation-friendly market regulation in the field of digital health (Advantages: optimize both economic and societal impact associated with changes of the legal framework done at the initiative of Ministry of Health and/or Ministry of Social Security in order to achieve a sustainable model of diversification).

2. Define **new funding schemes** to stimulate demand for digital health products or services by healthcare professionnals (Types of funding(s): PPPs (Public Private Partnerships), PPIs (Public Procurement of Innovative Solutions), PCPs (Pre-Commercial Procurements). Advantage: stimulate demand by healthcare professionnals and help companies bridge the pre-commercialisation/early commercialisation gap by allowing organizations to test and evaluate their products/services - benefit for patients/cost – and, afterwards, get a better chance to enter the marketplace through specific reimbursement scheme).

3. Creation/implementation of a **quality label for digital health products/services** to stimulate demand by citizens (Advantage: build trust and reduce risks associated with digital health products/services in order to help citizens making informed choices, thereby favoring diffusion of innovation).

4. Create a **digital health Living Lab** to make innovation supply meet market demand in digital health (Advantage: allow technology developers to take into account needs, experiences, uses and ideas of citizens, patients, healthcare professionals in the design, development and evaluation of innovations).

5. Make reflections and assessments on establishing **tax measures** to encourage innovation in firms in the pre-commercial phase.

6. Leverage **synergies with the EC Digital Pole (DG Connect & DG IT)** in Luxembourg to position the country as a population health data analytics hub (Advantage: capitalise on EC strengths to federate local and european capabilities to capture the value of anonymous health data to support public health policies and PPPs).

5.5

Space

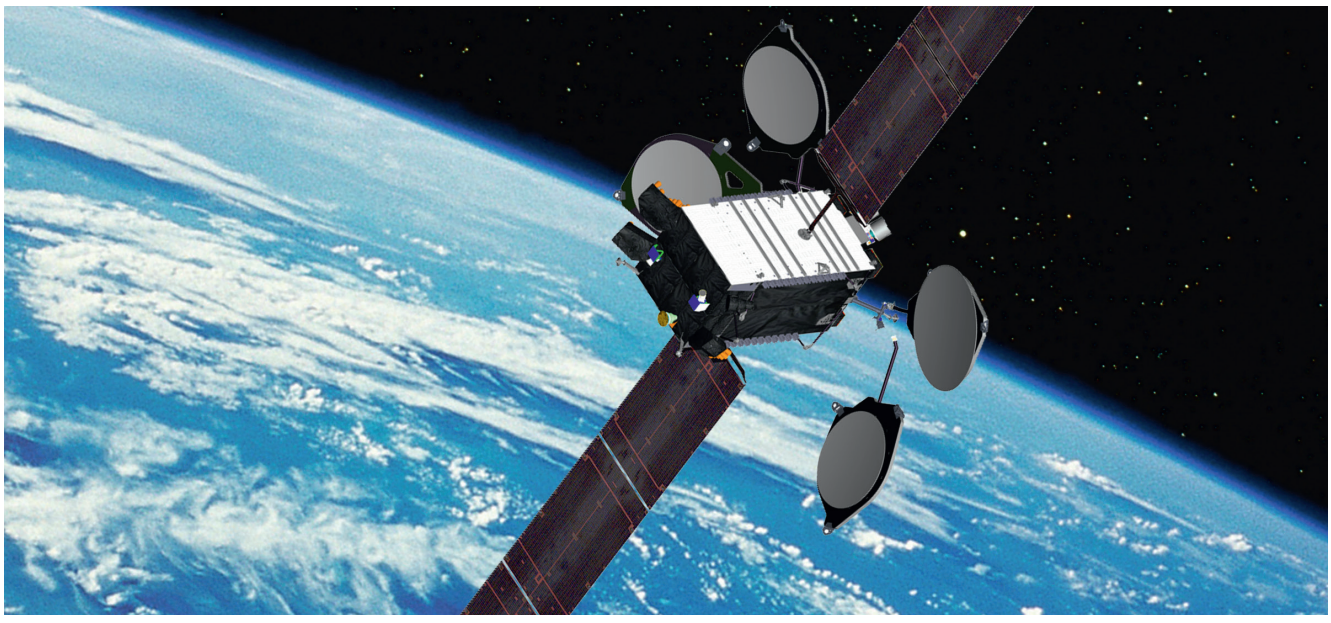
5.5.1

Context and vision

Space technologies, data and services have become indispensable in the daily lives of Luxembourg and European citizens: when using mobile phones and car navigation systems, watching satellite TV or withdrawing cash. Satellites provide immediate information when disasters, such as forest fires or floods strike, allowing emergency and rescue teams to better coordinate their efforts. Agriculture benefits from improved land use. Transportation and energy infrastructure is safer and can be more efficiently managed thanks to satellite technologies. Global challenges due to growing populations, increased demand for resources and climate change require information about our planet which space based solution can provide more easily. Space is also of strategic importance for Europe. It reinforces Europe's role as a stronger global player and is an asset for its security and defense.

Europe has a world-class space sector, with a strong satellite manufacturing industry, which captures around 33 % of the open world markets, and a dynamic downstream services sector with a large number of SMEs. The European space economy, including manufacturing and services, employs over 230.000 professionals and its value was estimated at € 46-54 billion in 2014, representing around 21% of the value of the global space sector [47].

In addition, competition is increasing; new entrants are bringing challenges and new ambitions in space. New acquisition and procurement approaches from governments and governmental agencies are creating new opportunities for innovative entrepreneurs. Space activities are becoming increasingly commercial with greater private sector involvement; and major technological shifts are disrupting traditional industrial and business models in the sector, reducing the cost of accessing and using space. All those factors have already enabled a new momentum in the commercialization of space, which will accelerate in the near future. The combination of space



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47 *European Commission 2017*

data with digital technologies and other sources of data open up many business opportunities for all Member States.

Of particular note is the uptake of space services and data. Data and services derived from space systems, including satellite images, geo-positioning information and satellite communications, already contribute to environmental protection to transport safety, precision farming, control of fishery stocks, monitoring of shipping routes and detection of oil spills, to urban and regional planning. The potential areas of application are huge and they are far from being fully exploited.

In the longer term, the uptake of space solutions by integrating space into future strategies addressing, for example, autonomous and connected cars, railways, aviation and unmanned aerial vehicles. Space and satellite communications solutions will also improve connectivity for Europe's digital society and economy. Satellites can provide cost-effective solutions in particular to connect assets and people in remote and offshore areas, or as part of the future 5G networks, where numerous applications and services using space data will also require uninterrupted connectivity.

This focus on digital technologies, on data and services derived from space systems, is reflected in the European Council adopted conclusions of the Competitiveness Council of 01/12/2017 which stated *"Space data has proved to have great potential for creating economic benefit and improving employment opportunities (…). The world has become digital and (…) space policy is an essential instrument for moving towards a digitized and data-driven economy in Europe".*

Finally, beyond this vision of a new space industry and space enabled data-driven economy opportunities described previously, is the emergence of a new space economy based on the utilization of resources that can be found in space. Today, all the equipment functioning in space to serve applications in telecommunications, navigation or Earth observation are all developed and manufactured on Earth before being brought into orbit using a rocket. The same raw materials we find on Earth are largely available in space and the ability to manufacture in space and to use the products in space opens unlimited perspectives to what humanity will be able to perform in space. The new capabilities related to the use of space resources will also be an enabler and an accelerator for future robotic and human exploration.

5.5.2

Luxembourg today and space as a new opportunity

Since the middle of the 1980's, Luxembourg is actively contributing to the economic development of the space sector. During the past 30 years, the country has proven to be able to anticipate future developments and to seize the identified opportunities. The most successful example being the creation of the Société Européenne des Satellites (SES), now the largest independent operator of satellite services in the world.

In order to stimulate innovation and technological development in the data space sector, Luxembourg contributes to several programs of the European Space Agency, in domains like space science, satellite communications, satellite navigation, Earth observation, space situational awareness and generic technology developments. Those contributions have made of Luxembourg one of the most active Member States of the European Space Agency. To complement those international programs, Luxembourg took another measure by setting-up a national space technology development program specifically dedicated to the technologies of interest to Luxembourg. This program is running with the support of the European Space Agency.

Through its forward-looking approach and policy, Luxembourg also contributes to and plays a key role in the future "in-space" economy. Luxembourg has defined several measures to be implemented to support the development of the space sector in general and the spaceresources.lu initiative in particular.

From a regulatory perspective related to the use of space resources, Luxembourg has already taken a first step through its law on space resources in force since August

2017. Thanks to this undertaking Luxembourg is the first European country giving certainty to the entrepreneurs willing to develop their activities on space resources.

Moving to a sustainable economic functioning of in-space activities will require significant funding. Of course, governments and governmental agencies will cover part of the financing needs, but most importantly, investments from the private sector will be required to complement institutional programs. Luxembourg is embracing this recent trend in the space sector leading to more and more privately initiated and funded space endeavors. To support this development, Luxembourg decided to set-up a dedicated space investment fund. This fund will make direct investments in specific companies.

5.5.3

Preparing the Space Economy

The Ministry of the Economy plans in the next five years to address two key opportunities; coupling traditional space sector actors with new "space data" enabled downstream opportunities in the data economy, and continuing to drive forward the future "in-space" economy. Five new policy and investment measures are proposed to best position Luxembourg along with horizon education support initiatives.

"Space data" enabled data economy

1. Addressing the European Competitiveness Council call for a stronger link between space and the digital economy by **putting in place the 21st century digital infrastructure**; high performance computing and Big Data analytics capabilities necessary for future new space data enabled applications and services.

2. In the frame of the joint EU and ESA initiative establishing a European Earth observation capability under the Copernicus programme, Luxembourg will provide a privileged access to users of this data through the so-called Copernicus Collaborative Ground Segment. This infrastructure will **offer access to the data produced by the Sentinel satellites of the Copernicus system** in order to stimulate their use and generate added-value services. Combined with the coming high power computing capability, Luxembourg will thus offer a unique framework for innovative entrepreneurs developing downstream applications using Earth observation data.

3. Space data coupled with digitalization will enable many sectors, such as meteorology, transport and logistics, agriculture, mobility, security and many others. Luxembourg will proactively **invest in companies using space infrastructure and data** to develop their services and competitive position.

The future "in-space" economy

4. International cooperation is a key success factor of the development of this sector. Luxembourg will **engage in a proactive international promotion policy** to create awareness about the opportunities. Luxembourg is actively looking to conclude agreements with like-minded countries to support and stimulate the development of in-space activities.

5. Pursuing a long-term in-space vision also requires additional regulatory initiatives; Luxembourg will launch a detailed study in order to **define the most appropriate procedures to authorize and supervise in a continuous manner the space resources related activities** pursued by private entities.

The Government actively supports the inclusion of space as an education tool, through the European Space Education Resources Office with the support of the European Space Agency a higher education programme at the University of Luxembourg, as well as research Laboratories at the University of Luxembourg and at the Luxembourg Institute of Science and Technology.

5.6

Logistics and Supply Chain Management

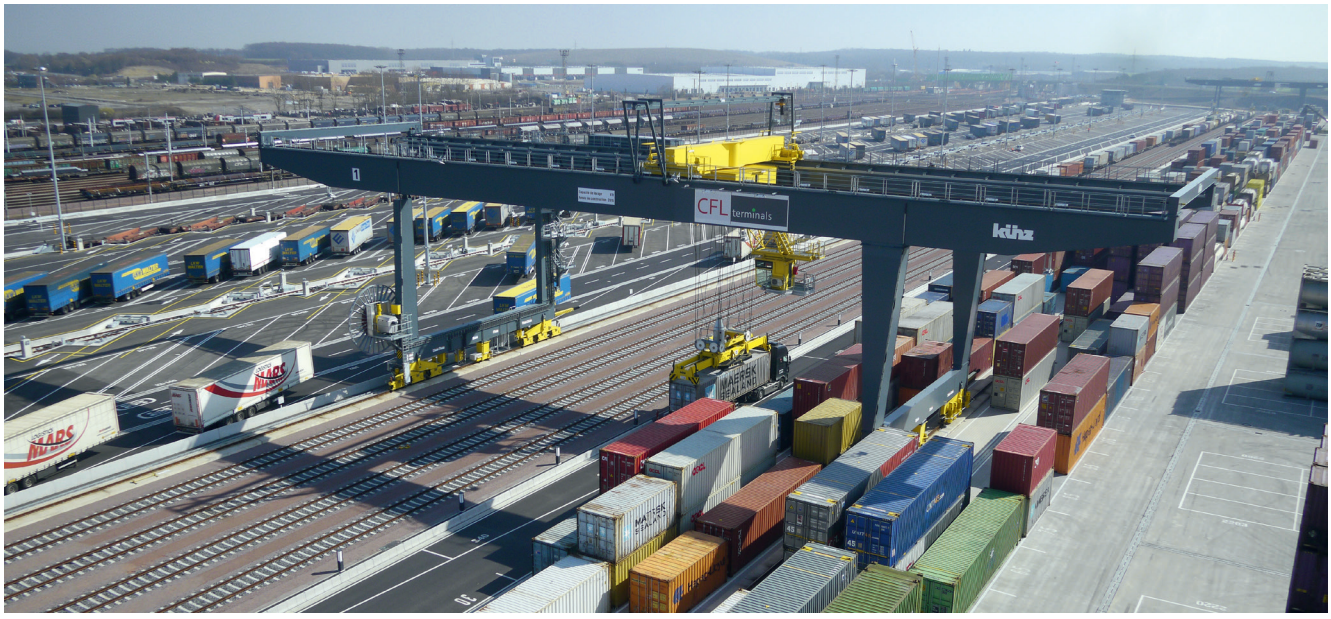
5.6.1

Context and Vision

If globalization has largely influenced the logistics sector over the last decades, new drivers, such as digitalization, new digital technologies and Big Data are about to disrupt and reshape global supply chain networks and their related logistics business models. Digitalization is already boosting cross-border e-commerce sales around the world, and as a result, it is transforming retail distribution channels and delivery services where customer expectations are driving more and more supply chain decision-making processes. Further, technological advances in the field of Internet of Things, Blockchain and automation, amongst others, are expected to reshape logistics processes along the entire logistics value chain from warehouse management to end-to-end traceability and route planning optimization. Finally, the interactions amongst the numerous partners (public and private) involved in global supply chains generate significant data that need to be processed efficiently in order to turn them into smart data.

Therefore, Big Data, analytics and artificial intelligence also represent a huge potential for the logistics and supply chain management (LSCM) sector, especially in terms of process efficiency, demand forecasting, inventory management, real-time end-to-end transparency and route planning. With regard to the adoption of new technologies, long established logistics service providers (LSPs) are already facing competition from new players such as Amazon that appear to develop, adopt and implement at a faster pace new technologies and Big Data analytics in order to optimize the underlying logistics services and processes related to their business activities.

Over the past decade, Luxembourg has continuously improved its positioning as an intercontinental and multimodal logistics hub in Europe for value-added logistics activities. In synergy with the other priority sectors, a



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multi-product specialization strategy has further been implemented within the logistics and supply chain management sector in order to develop tailor made solutions for certain types of products or industries that require specific handling and/or storage solutions such as pharmaceuticals, high valuables or parcels delivery generated from cross-border e-commerce sales.

In order to further ensure a sustainable growth of its logistics and supply chain management sector, Luxembourg should aspire to become a next generation logistics 4.0. hub, where established LSPs have consistently incorporated digital technologies into their business model and their operational activities as well as offering a favorable ecosystem to new companies aiming to develop innovative logistics services from Luxembourg.

With this ambition in mind, the expected impact of new disruptive technologies on the different activity fields within the LSCM sector present in Luxembourg is being investigated. A focus is on the current key strengths of Luxembourg's LSCM sector such as the logistics activities linked to pharmaceutical products, cross-border e-commerce or the freight activities revolving around the cargo centre at the airport. The sector will leverage Luxembourg's ICT, start-up, research and innovation ecosystem in order to stimulate new digital solutions amongst and for the LSPs in Luxembourg as well as for attracting innovative start-ups.

Finally, Luxembourg needs to improve the speed and efficiency of administrative processes by supporting digitalization within the administrations involved in logistics flows from custom's processes) to multimodal traffic management.

5.6.2

Luxembourg embraces the digital revolution in logistics

As logistics companies move and track goods all over the world through their global networks by interacting with numerous public and private partners, they gather very significant data. However, they need to upgrade this into smart data, which is currently hardly the case. It is not that LSPs do not see the benefit. Many of them have high expectations for better using the data they are generating but they have difficulties in extracting the right insights in order to turn them into actionable measures for increasing their supply chain operational efficiency. Other LSPs, especially SMEs, are likely to require the assistance of external service providers, which help them with the adoption of digital technologies and the relevant utilisation of the resulting data. Innovation in LSCM is thus essential, as it will reinforce Luxembourg's competitiveness in this field.

5.6.3

Key initiatives for the forthcoming years

In order to stimulate the adoption and the implementation of digital technologies, the following measures are suggested:

1. **Learn from other logistics hubs and raise the awareness among Luxembourg's logistics stakeholders on the benefits of digitalization, new technologies and Big Data**
   As the digital transformation will be an ongoing process for years, it will be essential to continuously raise awareness among all stakeholders by organizing field trips abroad (at company or hub level) in order to discover and adopt innovation best practices or by supporting dedicated events, such as, the organization of Logistics Innovation Awards.

2. **Assess the level of digitalization and define technologies to focus on**
   Before defining new policies, it will be important to assess the level of digitalization within the Luxembourg-based LSPs. An innovation gap analysis would provide an understanding of which are the technologies early adopters are focusing on in Luxembourg and the challenges faced by followers.

3. **Encourage cooperation between companies and public research institutes**
   Building on the cooperation already existing amongst

Luxembourg public research institutes, efforts will be made to improve coordination amongst ongoing projects and encourage further collaborations with the Luxembourg logistics industry.

4. **Define and leverage synergies with the other priority sectors**
   Reflecting a multi-sectorial optimisation strategy, it will be opportune to define some key projects in synergies with other priority sectors; for example, in the field of autonomous driving, Blockchain or Internet of Things.

5. **Support companies' in-house innovation**
   It is important to support the LSPs engaging in in-house innovation, by explaining Luxembourg's innovation ecosystem and the instruments available such as collaboration capabilities with the public research institutes or the funding schemes.

   Currently, the Minstry of the Economy encourages major LSPs to set up innovation centers in order to accelerate digital transformation within their group of companies.

6. **Leverage the start-up ecosystem**
   New innovative digital solutions and business models will most likely be generated from innovative start-ups. Therefore, we need to leverage Luxembourg's start-up ecosystem that already supports to a certain extent logistics and supply chain management.

   The Ministry of the Economy should support start-ups at an early stage by organizing a Fit4Start edition with a logistic chapter and try to attract late-stage start-ups that are looking for a platform to expand their European activities.

7. **Availability of data and data sharing**
   Luxembourg already offers a state-of-the-art ICT infrastructure (e.g. data centers), internet connectivity and in the near future a HPC competence centre. However, the availability of relevant data is often one of the critical resources that innovative early stage start-ups need for developing new solutions. In this respect, it should be explored how to make available or share data collected by Luxembourg's public administrations (e.g. traffic data from CITA) or by companies' after having anonymized and aggregate them in order to preserve confidentiality. The sharing of these data could be organized via a "logistics data platform". Data sharing among the different actors along the logistics value chain needs to be encouraged, as data availably will be instrumental for stimulating new innovative business models.

8. **Develop skills**
   A significant future challenge in relation to digital transformation will be the availability of skilled people. Therefore, it will be important to attract new talents to Luxembourg as well as support dedicated training and lifelong learning programs.

   However, as not all LSPs will have the need nor the resources to hire data scientists, it will also be important to train people that understand these new technologies in order to be able to integrate them (e.g. via software integration) within companies, especially SMEs. Therefore, it will be important to integrate courses focusing on new digital technologies and software integration in current logistics training programs.

9. **Monitor EU policy developments on digitalization of transport and logistics**
   Digital transformation of the logistics sector will also involve the adoption of new EU policies. Therefore, there is a need to continue to monitor and participate in the ongoing EU initiatives at public policy level. This will require a high level of inter-ministerial coordination effort given all the working groups or initiatives that could influence the digitalization of the logistics sector.

10. **Create a Logistics Digital Lab**
    To coordinate all these initiatives, a Logistics Digital Lab should be created in Luxembourg. It does not necessarily need to be a new entity, but rather a coordination platform between all the actors that could also raise awareness, cooperation and synergies.

5.7
Financial Services

5.7.1
Context and Vision

Digitalization of core segments of the financial services industry such as banking, payments, insurance, financial markets and asset management is taking place on a global scale. It is led by large international players and accelerated by innovative fintech start-ups that have raised more than USD 60 billion in the last three years alone. Today, more than 25% of the global population is already using at least one financial technology innovation [48].

Financial services are moving into the digital era and face the transition from batch processing of data to real-time data-driven business applications, considered by industry experts as one of the key challenges for the coming years.

Big Data and AI are therefore set to strongly impact these sectors and the way financial institutions currently operate. On the one hand, organizations must be highly responsive towards meeting fast changing customer demands in order to retain their clients. Technologies such as AI and Big Data empower real-time smart applications that can offer an array of personalized services to customers.

On the other hand, digitalization coupled with AI and Big Data technologies allows the optimisation and automation of an increasing number of administrative (middle-office and back-office) processes. Cybersecurity and fraud detection is another major concern of the financial sector where digital ID management and AI can play a growing role.

This evolution towards a data-centric industry is happening under the supervision and guidance of the financial sectors regulators and the implementation of recent European Union regulatory frameworks such as the payment services directive (PSD2) is accelerating data enabled business models. In the new "Banking-as-a-platform" era, third-party service providers will offer

[48] *Frost&Sullivan: AI and Big Data Technologies Transforming Financial Services, September 2017*

their products and services to a bank's clients via APIs [49] and 1.7 billion API transactions in banking are expected globally for 2023, at an 22.4% annual growth rate. [50]

A data-driven strategy has therefore emerged as crucial for the future competitiveness of leading financial centres worldwide.

5.7.2

Luxembourg, a leading financial centre in Europe

Luxembourg is the world's largest cross-border fund distribution hub with over € 4.3 trillion assets under management, it is equally the number 1 Wealth Management Centre in the Eurozone, the number 1 in cross-border insurance and operates the only Green bond Exchange in the world [51].

The banking, insurance and asset management sector accounts for over a quarter of Luxembourg's GDP, without taking into account service providers such as law firms, audit firms, system integrators and data centres whose business relies heavily on the financial services sector.

In 2013, the Luxembourg government identified financial technologies as a priority within the economic development strategy in order to enhance competitiveness by accelerating the adoption of innovation within Luxembourg's financial centre. To do so, Luxembourg initiated a PPP foundation named the LHoFT (Luxembourg House of Financial Technology), to act as a fintech hub gathering leading industry players and governmental institutions.

As a result, the Fintech ecosystem has grown considerably over the course of the last 3 years and fintech start-ups from all over the world are starting activities in the Grand Duchy, attracted by a stable environment, its stringent and tech-savvy regulators and its truly international financial centre.

5.7.3

Remain a leader in the digital era by developing new financial services activities in the data economy

There is an opportunity to create a unique data-driven environment in Luxembourg where the global trends towards real-time digital financial services can play a central role to fuel the next wave of growth of the financial centre. To do so, it is necessary to:

1. Develop **new RDI financing tools and support programmes** tailored to the financial sector players. These programmes should be taking into consideration the specificities, challenges of the sector (regulation, data security, data confidentiality, complexity of testing solutions, etc.), and foster the usage of new technology solutions such as Blockchain, AI and data analytics. They should focus on supporting data-driven projects with high potential for the Luxembourg financial centre's activities within the larger players and support the thriving fintech ecosystem.

2. Develop **specific schemes to attract and retain talented employees** such as data scientists / analysts and engineers in order to facilitate the creation of data-labs within larger financial services groups and allow the smooth development of fintech start-ups.

3. Work with financial sector players (banks, investment funds, insurances, etc.) to **increase the usage of Luxembourg as their central European hub** where data is collected, exchanged, processed and valorised. The country's long track record in managing compliance for complex financial products, securing sensitive data and distributing financial products and services cross-border is an asset when moving into the data-driven business models. Within this framework, financial sector players should explore how to leverage, in compliance with all regulatory requirements, their data assets in other activity sectors.

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[49] *API stands for Application Programming Interface and it is a software intermediary that allows two applications to talk to each other.*

[50] *Frost&Sullivan, 2017: Banking-as-a-Service to Bring Agility and Flexibility to Financial Services, Forecast to 2023*

[51] *All figures on the Luxembourg financial center as of September 2018. Sources: Alfi, CSSF, CAA.*

4. Develop **public private partnership projects** to integrate financial technologies and related data analytics (smart insurance, digital payments, project financing, lease financing, etc.) in identified sectors of interest such as "circular economy", "sharing economy" or "autonomous vehicles" as enablers for a faster customer adoption and sector development.

5. Tailor future **international prospection activities** to identify Big Data companies, within the selected priority sectors, with ambitions to develop financial services activities in order to grow further the Luxembourg financial centre. This reflects the realisation that the digitalization of the economy has created a new breed of financial players, which are data centric high-tech companies with large customer communities and strong business cases to integrate financial services in their core offering.

6. Support the **development of new initiatives** aimed at facilitating investments in data assets that value the level of digitalization and data-readiness of companies as key investment criteria, in collaboration with the Ministry of Finance, Luxembourg for Finance, the LHOF and other established financial sector players.

6 EXAMPLES OF THE EMERGING DATA-DRIVEN ECONOMY IN LUXEMBOURG

Within less than a decade, most economic activity will depend on digital platforms and ecosystems, integrating in different ways digital infrastructure, hardware and software, applications and data. The coming decade will therefore see the unrelenting emergence of new data-driven economies and new industry players. Examples of the already emerging "data economy industry" in Luxembourg include:

ICT sector

An example of a Luxembourg player in this emerging data enabled economy is TalkWalker, a Big Data company, which focuses on social media analytics and has grown to 120 people in just four years. Another example is EXCELLIUM which proposes services for the protection of data generated in the context of intangible assets in companies (IoT).

Manufacturing sector (Industry 4.0)

Already several companies in Luxembourg are transforming their enterprises to implement digital manufacturing. Paul Wurth have developed a predictive maintenance tool for smart blast furnaces with significant market potential. Husky Injection Molding Systems have implemented a digital manufacturing process that can significantly reduce the total time from order to manufacture to one day.

Circular Economy

In Luxembourg both LIV Services and Eiravato are examples of emerging data enabled companies in this sector. LIV Services provides consulting and digitalization services and makes sure customers have access to the digital tools they need to succeed in a circular world. Eiravato has set out to completely disrupt the manner in which companies dispose of unused materials in their manufacturing processes via a cloud-based platform, harnessing the power of Big Data and AI.

Smart Mobility (Automotive industry)

A strategic example is Goodyear, which has recently launched a new predictive maintenance service for commercial vehicles based on data from tyres whilst SES, a world-leading satellite operator is developing automotive satellite connectivity solutions for connected cars.

Health technology

One example of a Luxembourg company in this new area is Doctena which focuses on digitalization of medical services administration. Another example is Arspectra which is a medical technology company specialized in the design of novel augmented reality solutions for the health market.

Space sector

Already, Luxembourg has attracted "NewSpace" companies such as Spire Global wich collects and analyses data from space to identify, track and predict the movement of ships and airplanes and to forecast weather systems to improve decision-making. Another example is Earthlab Luxembourg, which offers global risk management solutions for insurance, strategic assessment and asset management by integrating earth observation data with many other sources of information to predict and optimize losses in case of extreme events.

Logistics and Supply Chain Management sector

Already several companies in Luxembourg have integrated or are offering data-driven solutions. For example, Champ Cargosystems offers integrated IT solutions for connecting the air cargo community. Further, several logistics service providers, such as Kuehne+Nagel, Panalpina, Wallenborn or Arthur Welter, offers Track & Traces IT Solutions for monitoring temperature control of pharmaceuticals shipments.

Financial Services sector

In Luxembourg, i-Hub is a new venture initiated by Post Luxembourg with the aim of operating a centralized and mutualized KYC repository. Its platform complies with the highest standards of security and regulation and reduces financial services players' compliance costs by decreasing client onboarding time. Another example is FundsDLT, initiated by the Luxembourg Stock Exchange, which uses distributed ledger technology (Blockchain) and smart contracts to make fund distribution more efficient. The platform connects data and processes related to transfer agent activities, payment systems and investors.

7 CONCLUSION

The emerging "Data-driven economy" constitutes both an opportunity and a competitive challenge for Luxembourg companies across all sectors. The opportunities will come predominately to those countries that are best prepared and equipped to compete digitally. As we will enter the third decade of this 21st century, digital data, digital infrastructure and digital knowledge are considered as strategic economic and competitive assets in all advanced nations.

For Luxembourg to benefit from the immense potential opportunities for innovation, productivity, growth and jobs, it must now accelerate its preparations for this future data-driven digital world. With this strategy, the Ministry of the Economy proposes specific measures with respect to the digital innovation policies and assets necessary to both support the emergence of a Luxembourg secure and trusted data-driven economy and to accelerate the digitalization-enabled transformation of its industry across key strategic domains of the Economy; ICT, manufacturing Industry, eco-technologies, health technology, space, logistics and financial services.

The proposed measures both leverage and build on the already established EU digital policy landscape, to which the Ministry of the Economy actively contributes through its participation in several European Commission and Member State High Level Groups, such as that on Digitizing European industry and Artificial Intelligence. The strategy also reflects the Digital Lëtzebuerg and The Third Industrial Revolution strategic orientation plan to usher in a smart green digital Luxembourg society, by addressing issues related to ICT data processing and energy sustainability. It is complemented by the Artificial Intelligence strategic version for Luxembourg wich will further boost investment into the data-driven economy.

In particular, the Ministry of the Economy will focus its digital innovation strategy for growth on the following key areas:

- **Boosting and assuring a world-class digital infrastructure**

  To ensure that Luxembourg public and private actors have access to the most competitive digital enabling infrastructure and platforms including High Performance Computing (HPC) and Big Data analytics.

- **Accelerating experimentation and up-take of new advanced digital technologies through support for platforms and testbeds**

  To ensure the development and accelerated application of general purpose digital technologies such as Artificial Intelligence coupled with Internet of Things (IoT) smart components, systems and networks, and HPC enabled Big Data analytics, in Luxembourg companies and product. In order to drive future growth in particular a Luxembourg Digital Innovation Hub will support Luxembourg SMEs to integrate innovative digital technologies, products and data-driven business models into their corporate business.

- **Implementing a strong regulatory, intellectual property, investment and financing environment**

  To ensure a world-class innovative regulatory and intellectual property environment coupled with the availability of strong investment and financing tools in Luxembourg.

In conclusion, the data-driven innovation strategy will ensure that **Luxembourg becomes one of the most progressive and attractive digital environment within the European Union for industry and business related data-driven economy activities across key economic sectors**. Its success depends on effective implementation of data and digital related innovation policies both within the Ministry of the Economy and across other Ministries and governmental agencies. This data-driven innovation strategy carries forward the core elements of the coalition agreement 2018-2023 signed on 3rd December 2018.

"The data-driven innovation strategy will ensure that Luxembourg becomes one of the most progressive and attractive digital environment within the European Union for business related data-driven economy activities across key economic sectors."

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Ministry of the Economy

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