UNIVERSIDADE CATÓLICA PORTUGUESA

Development of a Data Report Structure for Porto City Council

Literature review and benchmark analysis on best dashboard design practices

Frederico Brandão Beleza Maciel

Universidade Católica Portuguesa
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Development of a Data Report Structure for Porto City Council.

Literature review and benchmark analysis on best dashboard design practices

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Frederico Brandão Beleza Maciel

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Professor Doutor Alberto Castro

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Resumo

Nas últimas décadas o mundo transformou-se a um ritmo muito rápido, através do aumento do tamanho das cidades, que se tornaram metrópoles em rápido crescimento. Devido à maior competitividade entre as cidades, os decisores políticos estão a explorar potencial infraestrutural e social, através da Tecnologia e da Inteligência para apoiar o desenvolvimento sustentável das cidades, tornando-as Inteligentes. A Análise de Dados, aplicando conhecimentos em estatística e outras áreas científicas e sociais, tem um papel crucial no apoio e desenvolvimento das Cidades Inteligentes. Nesse sentido, a Câmara Municipal do Porto está atualmente a desenvolver uma ferramenta de Business Intelligence & Analytics, o *Leme*, sob a forma de um Dashboard focado na atual situação económica do Município. No presente estudo, pretendemos realizar uma revisão da literatura sobre os princípios de design para dashboards urbanos e uma análise de benchmark do dashboard Municipal de Dublin. O nosso objetivo é demonstrar que é possível a Câmara Municipal do Porto desenvolver tal projeto, extraindo também algumas orientações para futuros desenvolvimentos.

Com a nossa análise à versão atual da plataforma, verificaremos que o software escolhido e os dados públicos disponíveis constituem uma boa base para um projeto desta natureza. No entanto, concluímos que a plataforma ainda não está pronta, e pode ser melhorada, através da individualização e customização de cada indicador. Concluímos que esta etapa é fundamental para eliminar os desajustes atuais que estão a diminuir a qualidade da plataforma. Concluímos ainda este projeto tem potencial para ser partilhado publicamente através de uma aplicação web, tornando-se uma referência para futuros desenvolvimentos, aumentando a proximidade com os cidadãos e melhorando o serviço público.

Palavras-chave: Data Analytics; Dashboard; Smart City 9899 palavras

Abstract

The last decades have seen the world demographics transform at a very fast pace, with cities increasing in size, becoming fast growing metropolitan areas. In order to increase competitive differentiation between cities, policy makers are exploring their physical and social infrastructure potential, using Information and Communications Technology and Intelligence to support their sustainable development, creating Smart Cities. Data analytics, which applies knowledge in statistics and other scientific and social areas, plays a major role on supporting and developing Smart Cities. Following this movement, Porto's City Council is currently developing a Business Intelligence & Analytics tool, *Leme*, in the form of a Dashboard focused on the current economic situation of Porto Municipality. In the present study, we intend to perform a literature review on the design principles for urban dashboards and a benchmark analysis with the exemplary Dublin Municipal publicly accessible dashboard. Our aim is to demonstrate that it is possible for Porto City Council to develop such a project, also extracting some guidance for future developments.

With our analysis to the current version of the created platform, we will find that the chosen software and the public data available constitute a good basis for a project of this nature. However, we also conclude that the platform is not yet ready, and can be further improved, specially through the individualization and customization of each variable. We conclude that this step is fundamental to eliminate present maladjustments that are decreasing the platform quality. In conclusion this project has the potential to be shared publicly through a web page application, becoming the core reference for further developments, increasing proximity to citizens, and improving public service.

Keywords: Data Analytics; Business Intelligence; Dashboard; Smart City 9899 words

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Introduction

As population concentrates evermore in cities, competition to retain and attract resources deepened, placing pressure on policy makers to pursue digitalization, transforming them into smart cities. (Berntzen et al., 2018). Dashboards are instrumental to that purpose.

This study aims to perform a Benchmark Analysis regarding Porto's Municipal Dashboard, starting by evaluating its current development status, and proceeding to sketch some guidelines regarding its potential impact in policymaking by **policy makers** as well as its use by its citizens, *"bridging the gap between government and the public"*(Matheus et al., 2020). Further to the scope just mentioned, it will also be considered the possibility of the dashboard operating as an enabler for the diffusion of public values such as equal access and rights, security, safety, transparency, honesty, responsiveness and accountability (Maheshwari & Janssen, 2014; Matheus et al., 2020).

The City Council's strategy for Porto's economy is to increase economic attractiveness, ultimately leading to the improvement of its citizens quality of life, as well as those who work and travel to Porto. With that in mind, it was developed a Project to create a **Business Intelligence & Analytics (BIA)** tool, *"Leme. – Sentir o Pulso Económico do Porto"*, a Municipal Dashboard, reporting the current Economic status of Porto Municipality.

Overall, this project aims to build a flexible, accessible, and intuitive platform, that would allow its users to perform an easy analysis based in a significant amount of information, allowing policy makers to improve their decision making, while increasing citizens awareness by easy access to relevant information about their Municipality.

On this context, this research aims to answer the following questions: Is it possible to construct a good Dashboard with Porto Municipality relevant Data? How? What improvements are necessary to achieve a clear and objective Dashboard? Can this project become the core for further developments in collecting and displaying other types of information?

In order to answer the aforementioned questions, this study is structured in the following way:

- Chapter 1: establishing the general framework that justifies the importance of this type of research.
- Chapter 2: Porto's economic context within which Leme was conceived.
- Chapter 3: clarification of problem definition and motivation for dashboard development.
- Chapter 4: explanation of research objectives and methodology.
- Chapter 5: literature review regarding public dashboard design recommendations and benchmark analysis of a public dashboard development.
- Chapter 6: Leme Dashboard structure and development analysis, current status and further developments.

1. General Framework

According to the report "Cities in the World- A new perspective on urbanisation" (OECD, 2016), demographics in the world is changing rapidly. In fact, the population living in high density areas more than doubled in the last 40 years, with big cities increasing in size and absorbing their suburbs and adjacent towns, evolving to metropolitan areas (OECD, 2020). Large metropolitan areas with over one million inhabitants grow faster than smaller ones, bringing demographic concentration to record levels, creating important policy challenges on several dimensions, including social and economic, environmental and health and public services (OECD, 2020).

The last years have shown that competitive differentiation among cities is increasingly dependent from people and their skills, knowledge, and creativity and consequently, from the capacity of the economy to innovate and attract and retain talent. To absorb and enable people's talent and creativity, cities need to develop a more citizen-centric approach to their services, with information technology and business intelligence and analytics being instrumental for that purpose (IBM Global Business Partners, 2010).This study also underlines that "Competitive differentiation today is more likely to be based on the ability of the workforce to create and absorb skills and innovation than on traditional drivers such as available natural resources, physical labour or manufacturing prowess."

Considering all the transformations that **society** has been going through in the last decades, namely the increase in population literacy and education, policy making should take advantage of the opportunities that arose with this **economic** shift, leaving behind old strategies of creating massive pools of undifferentiated labour force. Instead, civic leaders should focus on creating integrated services systems, built and designed to support and optimize highly skilled, creative and innovative communities and knowledge-intensive businesses (IBM Global Business Partners, 2010).

Pressured by fast growing Metropolitan areas and increased demand for resources and overall quality of life, Governments all over the world are pursuing the Smart City concept in order to support sustainable development through the use of Information and Communications Technology (ICT) and intelligence (Berntzen et al., 2018). Although there is no single definition for "smart city", a broader one can be used: "Connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city" (Chourabi et al., 2012; Harrison et al., 2010).

Data analytics plays a major role in the support and development of Smart Cities (SC). In order to better understand this importance, we first should characterise SC in three different layers: "Instrumentation", "Interconnection" and "Intelligence" (Berntzen et al., 2018). The Instrumentation layer begins by essentially collecting and filtering data from several sources, constituting the input of the system. Nowadays, data are being generated from multiple sources at such a high pace and volume that it became known as Big Data. These sources are everywhere and can be smart phones, computers, sensors and cameras or even people and institutions (Pan et al., 2016).On a second layer, is the interconnection process which integrates and transforms data into a format that may support decision making processes. We can look at this step as a refinement process of data. The Intelligence layer is perhaps the least studied but nonetheless the most important one when it comes to decision and policy making. At this level, business intelligence and analytics are used upon the collected data, in order to better visualize and understand them and, ultimately, facilitating informed and improved decision making (Berntzen et al., 2018).

It is particularly in the Intelligence level of SC that Data Scientists and decision makers use Data Dashboards, a specific tool of Data Visualization and analysis. To better understand this tool, let us look at Gartner's definition:

"Dashboards are a reporting mechanism that aggregates and displays metrics and key indicators so they can be examined at a glance by all possible audiences. Dashboards help improve decision making by revealing and communicating contextual insights into metrics to display indicators with intuitive visualization, including charts, scales, gauges, and traffic lights that show indicator progress toward defined goals" (Gartner, 2021).

When applying knowledge in statistics and other social and scientific areas to Data analysis, Data scientists are able to examine, group and visualize Data to an extent where descriptive and even predictive analytics are obtained (Matheus et al., 2020). Another important benefit of creating and organizing Data into Dashboards, is the communication and interaction with the public, that leads to their empowerment and the creation of Smart Citizens (Kalampokis et al., 2013; Matheus et al., 2020).

2. Context

Although Porto City Hall serves only 231 828 inhabitants within its Municipality (INE, 2022), it is the center for Porto Metropolitan Area, that has been steadily growing during the last decades reaching a total population estimated in 1,736, 491 people in 2021(INE, 2022).

Situated in the Northwest of the Iberian Peninsula, Porto is its social and economic core, assuming a strategic position as one of the main industrial exporters, while becoming an increasingly attractive tourist destination, through its recent urban revitalization, that led to a bigger international exposure and investment attraction capacity (Porto, 2022).

Porto's main economic activities are in the Services sector, with special relevance to Healthcare, Tourism and Education, with a recent growth in other activities deeply connected to the Information Technology (IT) sector, along with other creative and technological industries (Porto, 2022). Among advanced economies, the Services sector tends to be bigger, centered in metropolitan areas like Porto and benefiting from their economies of agglomeration, commuting zones and access to information technologies and other amenities (OECD, 2020).

Nowadays, with economic and social globalization creating simultaneously competition and cooperation on national and international levels, policy makers feel the increasing need to support their decisions with the best information possible (Kitchin et al., 2015). To develop relevant studies that could positively impact policy making, attract investment and inform its citizens, Porto's City Council created the Information & Strategic Studies Cabinet (GIEE) as a subdivision of its Municipal Department for the Economy. It was within this cabinet that my internship was done, with the purpose to analyze the creation of Leme.

3. Problem Definition and Motivation

GIEE is currently developing a **Business Intelligence & Analytics (BIA)** tool, *"Leme. – Sentir o Pulso Económico do Porto"*, a Data Analysis and Report structure in the form of a Dashboard, primarily focused on the current economic situation of Porto Municipality. Ultimately, such tool would allow policy makers and civic leaders to access high-quality data, facilitating better data driven decision making (Chengalur-Smith et al., 1999). The name *Leme*, the Portuguese word for rudder, suggests the projection of guidance given to its users, whether decision makers or general public.

To fulfil such purposes, it must accomplish the following objectives: study the Municipal attractivity to national and international investors; analyse the entrepreneurial and business dynamism; get a good overview of the economic structure; characterize the current human capital, its talent and qualification, and its potential to propel economic and productivity growth. Focusing in such detailed and specific objectives is particularly important for the City Council, as the key purpose of this project is to be proactive, avoiding the mistakes of dashboards that fail to gather interesting and insightful enough data to trigger decision making (Matheus et al., 2020).

Another major concern in this project's design is the importance that was given not only to Descriptive tools, but also its focus on Predictive, benefiting from the huge potential that big data has when using analytics for deeper insights and better decision making practices (Al Nuaimi et al., 2015). To build this platform, the first phase involved Data Gathering and Visualization to obtain an overview of Porto's current social and economic status and recent evolution. Next, the Data Prediction phase could give more insight into new trends and predictions that would improve knowledge and ultimately decision making.

Regarding data visualization, a user centric approach is required, allowing the user to perform the most suitable research for him, either macro or micro analysis, according to his needs and data granularity.

Such high complexity project is, obviously, a gradual process, that requires constant updates and maintenance.

Regarding calendarization, the project is divided in two phases:

-First: Data aggregation and treatment platform (Dashboard) design and construction, and its placement in a cloud support.

-Second: Platform optimization, focusing on its functionality's development as well as new functionalities creation.

As of this date, phase one of the project is already concluded, the Dashboard is created and is scheduled to enter on phase two during 2022 first Quarter.

4. Objectives and Methodology

With the project ongoing and phase one finished, the City Council already has the first version of the Dashboard operational and running. Although this is still an initial version, this platform is already a very interactive and useful tool, gathering relevant and good quality data from several data sources.

Now that phase two is being launched, this research proposes to perform a literature review on the issue of Urban Big Data, more specifically, on the design principles for urban Dashboards, with a special interest in its value creation and benefits, as well as its main risks and challenges. It will try to answer the following research questions: Is it possible to construct a good Dashboard with Porto's Municipality relevant Data? How? What improvements are necessary to achieve a clear and objective Dashboard? Can this project become the core for further developments in collecting and displaying other types of information?

A literature review on the issue of Urban Big Data will furnish a theoretical and empirical background. It will focus on the design principles for urban Dashboards and on a benchmark analysis on the design, challenges, and development of an example of a Municipal publicly accessible dashboard, providing some guidance for future developments.

Another important part of this work is related to Porto City Municipality long-term objective of preparing this platform for the possibility of opening its access to external users and ultimately to its citizens. Such perspective sees the Dashboard as an instrument in achieving higher levels of transparency and openness, increasing the efficiency of resource utilization, thus improving quality of life (Al Nuaimi et al., 2015). A technology that typically is point and click and

requires no expertise to interpret, can actually be a useful tool for civic engagement (McArdle & Kitchin, 2016).

This work will also perform a benchmark analysis on the design, challenges, and development of the Dublin Dashboard (https://www.dublindashboard.ie/), a publicly accessible dashboard that provides to the public an overall view of Dublin performance (McArdle & Kitchin, 2016), aiming to study and elaborate some guidance for future development of Porto's BIA project, giving some insights on the main design challenges and benefits for this future endeavour.

5. Literature Review

5.1. Big Data in Smart Cities: Public Dashboard Design

5.1.1. Data as an abstraction of reality and Data Science as the discipline to make sense of it

All too often Data is viewed as a homogeneous concept. In fact, it comes in various forms, as symbols that represent properties of objects, events, and their environment, as products of observation. However, Data is not useful until it is processed into relevant form, by being put in context to enable interpretation, ultimately becoming information (Ackoff, 1989). It is in the process of inferring information from data, that the answers to questions as *who, what, where, when* and *how many* are answered (Ackoff, 1989).

The process of data collection, analysis, interpretation and ultimately usage requires deep technical knowledge and expertise, to avoid data misuse, deliberate bias, data omission and manipulation, validating the obtained results with the data from the surrounding reality (Janssen & Kuk, 2016). These concerns are answered by Data Science.

According to literature, Data Science is a technical field studying major areas of technical work in the field of statistics. It encompasses six areas: multidisciplinary investigations, models and methods for data, computing with data, pedagogy, tool evaluation and theory (Cleveland, 2014). This discipline is of huge importance for governments and public institutions, that have been collecting increasing amounts of data on several areas (social, economy, environment, energy, resources, education, traffic, etc) (Matheus et al., 2020), combining them with other data that private organizations and citizens are turning public, collected through sensors like the Internet of Things (Janssen & Kuk, 2016; Pan et al., 2016). In fact, data scientists apply deep knowledge in

statistics and analytics for data analysis, supporting their work in visualization tools and predictive techniques, increasing knowledge, and discovering new trends and patterns oblivious to the naked eye (Matheus et al., 2020).

5.1.2. Big Data, Smart Cities and Smart Citizens

In their work "Understanding Smart Cities: An Integrative Framework", Chourabi et al. (2012) found a big diversity of definitions for Smart City, stating that "Although there is an increase in frequency of use of the phrase "smart city", there is still not a clear and consistent understanding of the concept among practitioners and academia.". The same study shows that depending on the literature field, its meaning differs substantially, including the replacement of the word smart with adjectives like digital or intelligent.

Some definitions focus more on the use of information and smart computing technologies as tools to "make the critical infrastructure components and services of a city – which include city administration, education, healthcare, public safety, real estate, transportation, and utilities- more intelligent , interconnected, and efficient" (Washburn & Sindhu, 2009).

Other definitions focus on the city performance and efficiency, when serving its citizens. In "The vision of a smart city", (Hall et al., 2000) defines smart city as *"a city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plans its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens"*, while (Giffinger et al., 2007) define as smart, *"a city well performing in a forward-looking way in economy, people, governance , mobility, environment and living,*

built on the smart combination of endowments and activities of self-decisive, independent and aware citizens".

Due to the conceptual openness of smart city, perhaps this concept could be summarized by as the joint efforts of a city infrastructure, businesses, technology and its people to potentialize its intelligence and increase its development (Harrison et al., 2010). Chourabi et al. (2012) follow such approach presenting that interconnection and joint efforts as *"a large organic system connecting many subsystems and components"*.

Overall, these various definitions of smart city bring the focus clearly on the city performance not only in developing its community's quality of life in a progressive and sustainable way, but also in transforming them into a smart community formed by "more informed, educated and participatory citizens, allowing their members to participate in the governance and management of the city and become active users" (Chourabi et al., 2012).

5.1.3. Dashboard: Business Intelligence Tool

Dashboards are an essential Business Intelligence tool designed to provide managers with a quick but insightful overview of a company or institution performance, and have been around for many years, replacing more traditional reporting methods (Velcu-Laitinen & Yigitbasioglu, 2012).

Gartner (2001) extends the definition of Dashboard: *"Dashboards are a reporting mechanism that aggregates and displays metrics and key indicators so they can be examined at a glance by all possible audiences. Dashboards help improve decision making by revealing and communicating contextual insights into metrics to display indicators with intuitive visualization, including charts, scales, gauges, and traffic lights that show indicator progress toward defined goals", emphasizing its role* as a reporting

tool. Meanwhile (Yigitbasioglu & Velcu, 2012) consolidate the concept by defining it as *"a visual and interactive performance management tool"*. In fact, it is the interactivity and adaptability of the dashboard to its users and their purposes that has increased its attractiveness in the private sector, fostering the acceptance and development of this type of tool (Velcu-Laitinen & Yigitbasioglu, 2012).

Over the years, due to the development of new IT systems and the data science field, dashboards have evolved from simple performance monitoring dashboards, with traditional indicators and metrics, to the incorporation of more advanced analytical tools, including features like scenario analysis (forecasting), drill down capabilities and presentation format flexibility (Velcu-Laitinen & Yigitbasioglu, 2012).

Regarding dashboards typology, some studies found and divided dashboards in three different main clusters: decision-making dashboards, static dashboards for awareness and dashboards for motivation and learning (Sarikaya et al., 2019).

Decision-making Dashboards support either strategic or operational decision making. Typically, they are highly interactive and targeted to organizations, allowing big adaptability to the viewer. In general, they allow for benchmark analysis, identifying high and low performing areas with focus on organizational improvement. They are usually used on a daily basis in businesses contexts and may show real time data (operational level) or over medium/long time data (strategic level).

Static Dashboards tend to lack interactivity with its users and are commonly used for general knowledge and awareness dissemination. They are the more traditional dashboards, typically shown in a static setting, to be consumed on a short time, usually displayed in a work environment. It may also

present real time data from sensors and some metrics, traditionally requiring low visualization literacy.

Dashboards for motivation and learning are generally found outside organizational environments and are targeted for particular purposes or general users. With the first aim, we find dashboards with interactive interface and based on alert systems, typically focused in areas such as finance, exercise and health or sleep. Dashboards aimed at a general use tend not to have alerting or benchmark features, opting instead to expose the data plainly allowing the user to come to an independent conclusion. In this subgroup we find dashboards for public health, public crime rates and other type of civic data.

However, this typology identification is not always evident: as dashboards evolved, they bring together traits and characteristics from different clusters (Sarikaya et al., 2019).

When assessing the benefits of Dashboards to the private sector, they are always correlated with organizational performance and efficiency, improved customer satisfaction, return on investment and increase in cash flow (Velcu-Laitinen & Yigitbasioglu, 2012).

However, when applied to the public sector, dashboards have a different purpose and therefore different design principles and benefits. This fundamental difference might be the cause of a diminished attention to the dashboard in the public sector, in contrast to its popularity among private companies and institutions (Maheshwari & Janssen, 2014).

5.1.4. Public Sector Nature

Although the need for dashboards to improve efficiency and performance in public organizations is already recognized as fundamental, public

organizations are still adamant to relinquish old and traditional reporting practices and processes which has hindered the research in the field of dashboard design for public sector (Maheshwari & Janssen, 2014).

In their work of 2014, (Maheshwari & Janssen, 2014) point out three main reasons for the limited use of dashboards in the public sector:

- The focus on public values instead of on profit;
- The fragmentation of responsibility over many organizations and the fragmentation of information sources;
- (Difficulty in) Gaining commitment due to the many actors involved.

When looking at public administration and policy, public values, along with political legitimacy and responsible government are critical factors. Furthermore, the more effectively the public institutions work to connect citizens to the world of politics, the more open and optimistic the community becomes about the future and their collective efforts (Jørgensen & Bozeman, 2007).

Equal access and rights, transparency, changes in law, honesty and integrity, impartiality, effectiveness, responsiveness and accountability cover a wide range of values that the community feels as essential in order to gain trust on political institutions and policy makers (Maheshwari & Janssen, 2014).

However, these values are not always aligned, making it difficult for political institutions to choose which values to prioritize on specific occasions. For example, opening a particular information to the public as a demonstration of honesty and openness can sometimes clearly conflict with the right of individual protection and the rule of law that guide Democracy itself (Jørgensen & Bozeman, 2007).

Another reason for the slow adoption of dashboards comes from the traditional fragmentation of public institutions tasks and responsibilities, associated with heavier and complex bureaucracy. Traditionally, public

organizations, because of the way they are structured, tend to struggle in terms of internal communication and alignment of objectives, resulting in internal tension and difficulty in assessing their true needs and how their interdependencies should relate (Maheshwari & Janssen, 2014).

Finally, as a direct consequence of the previously stated, public sector organizations face enormous difficulty promoting internal commitment towards structured and clear objectives, in addition to the lack of incentives for public servants to adopt new changes, requiring more work as compared to maintaining old habits (Maheshwari & Janssen, 2014).

5.1.5. Development of Public Sector Dashboards: Benefits, Risks and Challenges

In their work "Data Science Empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities", Matheus et al., 2020, through literature review and supported in the investigation of two study cases, present the main benefits, risks and challenges of public sector dashboards, and propose design principles for an effective application of this tool.

5.1.5.1. Benefits of public sector dashboards

The development of dashboards in the public sector is often based on a variety of purposes, such as empowering the public by creating transparency and accountability, performance monitoring, reporting, planning, policymaking and reduction of information asymmetry (Matheus et al., 2020). This is particularly relevant, since it is by providing more insight to the public, trough data aggregation and visualization tools like dashboards, that public institutions

promote the creation of smart citizens (IBM Global Business Partners, 2010). The main benefits of dashboard applications are summarised in Table 1.

Table 1- Public Sector Dashboards benefits

From "Data science empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities.", by R. Matheus et al, 2020, *Government Information Quarterly*

Benefits	Description
Strategic and political benefits	
1. Overview at a glance	Dashboards permit flexibility to create various types of overviews at glance. This enables different stakeholders to gain insight easily.
2. Drill into detail	The same flexibility that allows a broad overview also can be used to drill into detail for any event. During traffic monitoring, it is possible to zoom in on accidents.
3.Transparency	Creating a view at a glance can provide transparency about a situation, combined with the ability to drill down to details to really understand the data and conclusions that might be inferred from it.
4.Customer/user-orientated presentation/visualization oriented	Dashboards enable the creation of customized views. In this way dashboards provide information to people at the time and place they really need it.
5.Identification of fraud and corruption	Anomalies and patterns in data can be used to detect corruption by showing them in dashboards combined with data analytics.
6. Visualizing trends	The information presented in dashboards concerns the trends or issues in the city. It is not necessary to know what is still good, but rather what is needed to avoid the worst-case scenario.
7. Accountability	The insights can be used to help hold organizations or people accountable for their actions (or inactions). This requires the possibility of following up the results from the data analysis at the institutional level.
Operational Benefits	
8. Better and faster decisions and policy making	Real time data can enable operational strategies based on specific situations and immediate decisions.
9. Mobilize external knowledge	External partners such as smartphone applications and media (radio, TV) can use and spread the same information used on dashboards, collaborating for better effectiveness and efficiency (for instance, operational traffic conduction).
10. Improving the effectiveness and efficiency of operations	Transparency of relevant information on dashboards in real time can improve the efficiency of operations with better management of many situations such as reduction of traffic congestion. The efficiency makes people trust the dashboard, improving the effectiveness of operations in the short and long term.
11. Disclose relevant information to people	Dashboards give people relevant information for real-time decision-making. If not used, they can be just an expensive data storage system.
12. Enable participation	Relevant information on dashboards gives people the opportunity to participate in public decision-making and policy- making.
13. Public participation in service improvement	Open data and accountable systems give people and enterprises the opportunity to create new ideas on data usage. Co- creation allows to combine the data to develop new applications.

Dashboards are designed for use by governments (internal) or the general public (external). Internal use has some similarities with private business

applications, developing performance dashboards focused on reporting, analysis, and monitoring for faster and more accurate decision-making, increasing the operational efficiency and effectiveness. On the other hand, external objectives are more focused on creating transparency, increase accountability and inform and mobilize citizens, developing their participation and interest on public decisions (Matheus et al., 2020).

One of the main concerns when developing dashboards and similar data gathering and visualization tools, should always be data quality. Only when data is properly cleansed and prepared it becomes appropriate to be subject to analysis and interpretation. Nonetheless, high quality data may sometimes come at a high price, which should always force public organizations to assess the cost to benefit ratio of acquiring a particular type of data (Janssen et al., 2015; Matheus et al., 2020). However, there are good data improvement and simplification techniques that help to increase data quality and improve data understanding and interpretation.

Another very important characteristic of data is its granularity and timeliness as well as its versatility to be accessed in different formats. In fact, Matheus et al., 2020 state that *"The possibility to drill into the details of time, data, place, and description is as important as having the high-level statistics…"*, showing that although high level statistics may be important to discover new trends and possible bottlenecks, the high quality of data per se is already very important to gain insight and quickly spot improvement areas. Also, the higher the quality and detail of data, the more versatile it can be used and visualized in increasingly different formats on the dashboards, such as graphs, tables, heat maps, cue cards and many more. Data versatility is regarded as very important since the same data, depending on its visualization and applied statistics can be used for different objectives.

Through the use of dashboards, Data science is a major player in increasing the quality and speed of decision making, whether it is by policy makers or the general public. In fact, this tool can improve the effectiveness and efficiency of public policies and operations. Another important benefit of public dashboards is the potential they have in increasing citizen and private sector interest and engagement in public policies, mobilizing external knowledge to use open public data, cooperating with public sector, and increasing the database quality, ultimately extracting more knowledge. The increase in public participation in decision making is directly correlated with the improvement of services.

Transparency improvement is a better option than enforcing an option that the public might not understand or even agree with. Using the public evaluation, feedback and improvement suggestions will ultimately benefit everyone, increasing the quality of public decisions, and giving governments the possibility to impact positively their citizens life. Dashboards are also key communication tools with the public, whether they are placed in strategic urban locations or available through technological applications accessible through smartphone or computers and can display real time or medium/ long time data according to its purpose.

3.1.5.2. Risks and challenges of public sector dashboards

As seen previously, dashboards adoption by public institutions are a powerful tool to increase transparency, accountability and further develop trust and engagement between citizens and the public sector. However, Matheus et al., 2020 alerts that the simple adoption of dashboards doesn't translate in those benefits per se. Dashboard design is essential when focusing on the aforementioned benefits, and to achieve optimum design, one needs to focus on the risks and challenges in dashboard development. The main risks and challenges on dashboard design are summarised in Table 2.

Table 2- Risks and challenges for Public Sector Dashboards design

From "Data science empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities.", by R. Matheus et al, 2020, *Government Information Quarterly*

Risks and Challenges	Description
1. Low data quality	If data is not properly cleaned via statistics processes, for example, bad data can lead to bad analytics and give people the wrong message and information. Wrong information is worse than having no information!
2. Fragmented responsibility for data quality	Many owners can rapidly decrease the quality of data and the information delivery on the dashboards
3. Limited readiness to adapt to new changes	Politicians and public managers can boycott the new system or new technologies for a variety of reasons, such as the elderly having difficulty using the technology or civil servants avoiding loss of their political power for decision-making on public policies.
4. Limited knowledge and no suitable staff	There are not many people having the capabilities needed to design and operate dashboards. As the number of qualified people is low, they are expensive and in high demand by the job market.
5. Wrong interpreting information	Incorrect or inaccurate data and information visualized using dashboards can reduce citizens' trust in government.
6. Wrong decision making and mistrust in government	Governments should take care when disclose data in dashboards. Part of those public dashboards will lead citizens' decision-making. If the public organization cannot deliver a proper level of public services, it will lead to mistrust in the government.
7. Reducing transparency	Although dashboards can enhance transparency, dashboards might only blur the picture by providing pre-defined views defined by those in power.
8. Lack of resources	The development of a suitable dashboard can be expensive as numerous factors must be considered during development. This might require many interpretations and continuous updating after completion.
9. No maintenance and updating	Data in a dashboard is not updated or the dashboard interface is no longer current. If dashboards do not perform well, citizens will abandon them and less likely trust them.
10. Predefined view (level of dashboard customization)	Showing to people a predefined way without being able to delve into details and to take complementary views might result in bias, not being able to see the complete picture and in distrust. Offering alternatives to customize visualization and showing alternative views can increase insights can improve governance and trustworthiness, avoids bias from governmental perspective.
11. Not being able to adapt to new developments	The use of dashboards can result in new detailed questions, which might require additional data collection, or new plans and strategies to reduce the impact of public decision-making.
12. Data privacy	If data is not properly anonymized, private data can be displayed erroneously.
13. No participation support	Our definition of dashboard suggests that there is some level of control or intervention possible. Engagement support, providing comments and suggestion is essential.
14. No institutional mechanisms	The results of the data science efforts can result in the need for taking actions, for example, to hold organizations accountable. This requires having institutional mechanisms in place.
15. Scarce usage	Scarce usage of dashboards by citizens may not bring the efficiency and effectiveness expected by government and the public.

Starting with the essential substrate for dashboard construction, data isn't always accessible with the highest quality, or at a reasonable price. And low-quality data has an high impact on the quality of the insights it may provide, going to a point where it can even induce in error analysts, creating false conclusions and leading to incorrect and counterproductive decisions. Misunderstanding of information should always be a major concern in dashboard design, and not only may come from low data quality, but also from improper design, such as wrongly chosen visuals, whether showing an overload, incorrect or incomplete information. Major errors in dashboard design can be so

dangerous, that ultimately can lead to a decrease in public perception of transparency. Moreover, when using dashboards to decrease the information asymmetry between citizens and government and increase transparency, public institutions become subject to higher control of the citizens. This increases accountability and forces public sector to create and use public institutions to follow up insights, knowledge, and relevant conclusions acquired through data science. Ultimately, as the authors state, *"The use of data outcomes requires institutional changes, also to ensure accountability. Only formal authorities, such as ombudsmen, ministries, politicians, and judges, can hold organizations accountable."*.

Another characteristic of a business intelligence project such as the development of a public dashboard, is its cost. This typology of projects can be quite expensive, since not only its development and design can use a lot of resources, but also good quality and useful data may come at a price. Adding to the initial cost of the development phase, specialized human resources can be hard to find.

As stated before, a project of this magnitude, importance, and exposure to the public, requires constant update and new development on a regular basis, avoiding the danger of keeping a standardized version in the long term, ultimately losing strategic and public interest, and becoming obsolete.

When designing and developing public dashboards, some major challenges and risks arise, related with the public institutions internal structure and dynamics. When data originates in different departments or even different institutions, data quality tends to decrease significantly, which may force an increase in the efforts of data cleansing and preparation.

As explored in the subchapter the Public Sector Nature, the acceptance of changes by civil servants is traditionally lower when compared with private sector. This characteristic increases the risk of boycott by politicians and civil servants of this typology of projects, refusing to use the dashboard and adopting

new technologies, based on the possibility and threat of loss of political power and independence in decision making.

Another important specific characteristic of public sector that needs to be considered, is the legal requirements to anonymize data, trying to respect citizens' privacy and legal rights. This process can be particularly expensive and require highly skilled techniques to anonymize data and avoid the risk individual's recognition.

5.1.6. Development of Public Sector Dashboards: Design Principles and Data Cycle

After the analysis of the main benefits, risks and challenges in public sector dashboard creation, Matheus et al., 2020 identified design principles as a guide for the best practices in dashboard development and a generic data cycle for public sector dashboard development. Believing that these principles can effectively lead to a better and more effective development of public dashboards, the author states that these principles do not need to be followed in its entirety, but depending on the specific project, they are useful to create transparency and accountability.

5.1.6.1. Design principles of public sector dashboards

Due to lack of reviewed articles and publications about dashboards development in public sector as opposed to private sector, the authors identified the design principles as well as their description for dashboard in public sector in Table 3.

Although it is stated that not all principles need to be applied per se due to intrinsic characteristics of each project, they supply a very complete guide to dashboard development, trying to answer the risks and challenges studied before, thus optimizing the benefits and proposed objectives.

Table 3- Public Sector Dashboards design principles

From "Data science empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities.", by R. Matheus et al, 2020, *Government Information Quarterly*

Principle	Description
1. Collect accurate and precise data	Governments must give the most correct and precise information, to prevent users from being unable to understand the data and being misled. Incorrect information in the dashboard can result in bad decisions.
2. Customize views	Dashboards should not be merely simple or generic visualizations; dashboards should contain customized views for showing the problem at hand. In this way decision makers and users can gain insight. Customized views can help them understand the situation. The design requires understanding of organizational strategies, viewpoints, business processes, indirect effects, decision support systems, and priorities. In the cases found in the literature review, separate apps are developed for each purpose to enable a clear view of the problem at hand.
3. Support different view	A single view might result in a limited picture on the situation. Different views can avoid bias and improve the understanding. By providing raw data, others can create new views which can result in updating the dashboard and improving usage.
4. Clear presentation	Dashboards enable the use of charts, graphs, pictograms, bars, and numbers, etc., to visualize information for monitoring and analysing performance. Dashboards should visualize data in and easy-to-understand manner. In our cases, the simplicity of the dashboards enabled their use by a broad public.
5. Offer decision making support	Relationships between performance metrics and organizational desires Support must be clear. Dashboards can provide decision-support to evaluate 'what if' scenarios and to use predictive analytics. This can help provide more insight into the situation and help decision makers. By providing insight into possible alternatives, the effect of choosing an alternative can be predicted in our cases.
6. Interaction support	Static dashboards often provide limited insight. More insight can be gained by providing interaction features, which enables users to view the data from various perspective, to suggest recommendation based on the data but also to provide feedback to improve the use. Real time information was a key element for supporting the decisions in the cases.
7. Provide overview and details	Dashboards should be able to deal with an enormous volume of big and open data. By providing an overview and the opportunity to zoom in on details, the high-volume of big data analysed was presented in a simple visual display.
8. Focus on creating public values	Merely visualizing data has limited use if this is not suitable for creating added value. Dashboards are difficult to develop, especially for big and open data. Often a business case is required to determine the added value. Dashboards should be designed to create public values like engagement, transparency and accountability and adhere to public values like privacy.
9. Ensure real time updates of data	Most dashboards are not based on real time data. Governments present dashboards of what has happened in the past and can use this to predict future events.
10. Ensure institutional support	The creation of transparency results in the detection of incorrect data or behaviour. For citizens, it is hard to take any action if there is a suspicion of fraud or corruption. It should be possible for citizens to report to an independent and trusted agency. There should be institutions to deal with such matters further.

Regarding major risks and challenges, starting with data quality, the focus is on collecting precise and accurate data that should be a major concern to start a business intelligence project. Avoiding any danger with data misinterpretation,

lack of clarity and potential wrong information is essential, especially in a public project that could undermine the confidence of citizens in public institutions.

When presenting and showing the data, it is important to consider the different dashboard users and their intentions. To accommodate different needs and objectives, the visuals need to be clear, avoiding overloading of data, and diverse, facilitating interpretation, even opening the possibility to access the raw data, and collaborating in the creation of new visuals and potential new insights. These design principles are related with the dashboard adaptability, which is an essential feature to achieve maximum efficiency. To increase dashboard potential, visuals customization is essential, avoiding generic visualizations, and providing each visual a specific design and treatment, allowing knowledge extraction and supporting decision making. All this while keeping them simple to effectively communicate with citizens.

Support to decision making should also be considered an essential objective. When using performance metrics, whether they are focused on the internal performance of the organization or the municipality, their relationship with the specified objective should be quite clear. In the case of a public dashboard, the definition of the municipality objective for a certain domain should always be easy to correlate with the displayed data.

A very important characteristic of good quality data is granularity and timeliness. The opportunity to provide an overview of data or going into detail is essential to deal with big volumes of data thus improving the quality of acquired information. These characteristics are also associated with the dashboard adaptability and ability to inform different kind of users.

Public dashboards may deal with different types of data, e.g., real time or medium/long time data. However, a public business intelligence project needs

constant update on the data, to avoid turning the project obsolete and counterproductive.

Ultimately, the focus and creation on public values should always be an important guide for public projects. Focusing on transparency and accountability should foster citizens engagement and participation in the projects. Adopting a design focused on these values is essential to serve the community. Assuring institutional support is the best way to assure accountability of public organizations. Perception of governments accountability is a core democratic value, and the best way to assure this, is guaranteeing that any insight or suspicion of corruption or fraud is possible to be reported and punished.

5.1.6.2. Data cycle for public dashboards

Based on the identified design principles, Matheus et al., 2020 designed and proposed a generic data cycle for a public sector Business Intelligence project, that ultimately reconciles the public interest of reducing information asymmetry and create transparency and accountability with the internal governmental interest for supporting and improving political decision making.

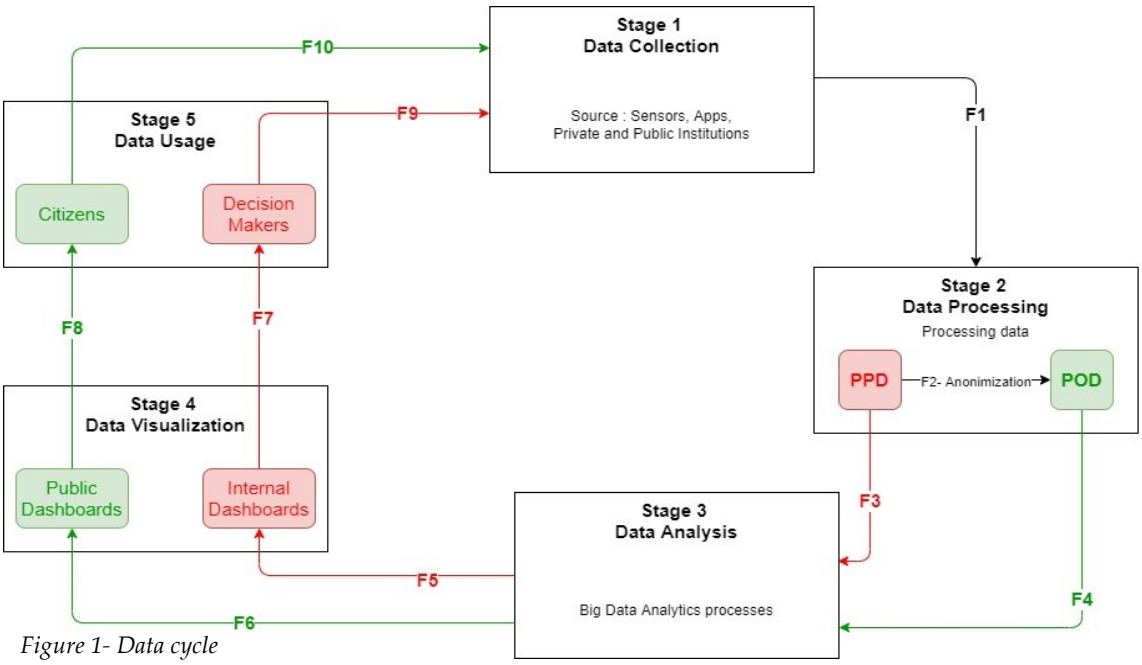

Figure 1- Data cycle

From "Data science empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities.", by R. Matheus et al, 2020, *Government Information Quarterly*

The data cycle model, structured to be applicable to a wide range of public B.I. projects, encompasses five stages: collection, processing, analysis, visualization, and data usage (Figure 1).

Due to its public sector nature, constraints, and characteristics, a B.I. project developed by a public institution should have two separated flows with different objectives: an internal flow that allows public organizations to create and follow internal strategies, and a public flow freely exploitable by citizens and enterprises preferentially through and open data portal. Except for the flow linking data collection and data processing, all the following stages are linked by those two different flows mentioned before circulating in parallel. A detailed description of data cycle flows is presented in Annex 1. One consequence of this data cycle design is that information asymmetry is not completely eliminated. In fact, by separating databases and creating two different data flows, PPD and POD, citizens will always have less information than their governments. However, creating dashboards that help citizens to understand a certain situation quickly and in the moment, avoiding long lasting search or information overload, is already a huge step in increasing their awareness and knowledge and increasing their access to quality information (Al Nuaimi et al., 2015).

The application of this data cycle design for a B.I. project, allows for the creation of a tool that not only can be used for policy evaluation, but can also be used for the entire policy making cycle, including policy formulation, implementation and evaluation (Matheus et al., 2020).

5.2 Dublin Dashboard: Benchmark analysis for Urban Dashboard Development

This subchapter introduces a benchmark analysis of an urban Dashboard, supported by the article *"The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard"* by Rob Kitchin (Dublin City Council, n.d.), the

coordinator of the team that developed the Dublin Dashboard. The nature of the project, its architecture, and challenges have similarities with Porto's case, thus increasing the importance of this benchmark.

5.2.1. Dublin Dashboard: General Framework and Characteristics

As cities scale increase, whether in economic, populational and physical dimension, their complexity and interconnections grow as well, leading to more difficulty in controlling them (Batty, 2009). To tackle these challenges, public institutions are increasingly using extracted knowledge from urban data, allowing them to better manage operations and infrastructure through better policy making and strategic decision (Kitchin et al., 2015), in the process of becoming smart cities.

For many of those cities, the smart city concept led to the development of urban indicator projects. Given Dublin's rapid economic and populational development in recent years, Dublin City Council launched a Business Intelligence project alongside Maynooth University involving Professor Robert Kitchin and his team, culminating in the creation and launch of the Dublin Dashboard in 2014, *"a publicly accessible dashboard which provides an overview of how Dublin is performing and provides intelligence to help citizens and city personnel to know and understand the city"* (Kitchin et al., 2015).

According to Kitchin, urban dashboards generally take two forms: dashboards which work as command-and-control centre (traditionally focused on a single thematic), or dashboards with open data to increase citizen engagement and allow everyone, public workers included, to explore and extract data. Nevertheless, there have been recent dashboard developments that try to combine those concepts, creating pan-optic views of many systems (McArdle & Kitchin, 2016), which is the case of the Dublin Dashboard.

The Dublin Dashboard is a hybrid dashboard combining and trying to connect real time and administrative data, provided in a single interface, keeping its primary objective in citizen engagement, but simultaneously giving public personnel the possibility to gather and extract important insights for policy making (Kitchin et al., 2015).

The incorporation of real time data and its mixing with administrative data, clearly distinguishes Dublin dashboard from traditional performance monitoring dashboards, possessing a wider range of visualization tools to allow more public engagement and simplify dashboard consultation. Additionally, the dashboard also provides its users with a variety of applications, some of them not even developed by public organizations, that gather relevant information about the city.

Another important characteristic of the Dublin Dashboard is the concern with minimizing development and maintenance costs. For that, the project uses only open-source data and tools and moulded the project architecture so that its tools could handle different variety of data formats, thus reducing its costs in formatting data.

5.2.2. Dublin Dashboard: Composition

The Dublin dashboard is composed by 11 modules which can be seen in figure 2 and are enunciated in table 4. Although some modules were built specifically for the project, many features included in the Dublin Dashboard were built externally for other projects, but since they serve the purpose of the project and show interesting data about the city, were included as part of the dashboard.

The first module, ***Dublin Overview***, is a specific module created for the project. This module intends to show in a simple way key indicators for the city. Through a single view together with an arrow indicating the trend, these key indicators are simple to read as intended, "The cognitive load required to understand this page is low" (McArdle & Kitchin, 2016). If the user wants to get more information, it is possible to click on the indicators and drill down through the data. Figure 3 shows the *Dublin Overview* landing page.

Table 4- Dublin Dashboard Modules

From "The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard.", by G.McArdle & R. Kitchin, 2016, *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, III-4/W1(September), 19–25.*

Modules
1. Dublin Overview
2. How's Dublin Going?
3. Real-Time Dublin
4. Dublin Mapped
5. Dublin Planning
6. Dublin Housing
7. Dublin Near to Me
8. Dublin Reporting
9. Dublin Data Stores
10. Dublin Apps
11. Dublin Bay Dashboard

Interestingly, this module mixes real time data, like travel time in main motorways, city parking spaces, water and sound levels or weather conditions at various locations while showing other administrative/ non real time data related to housing, crime, and health.

Figure 2- Dublin Dasboard Modules

From "The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard.", by G.McArdle & R. Kitchin, 2016, *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, III-4/W1(September), 19–25.*

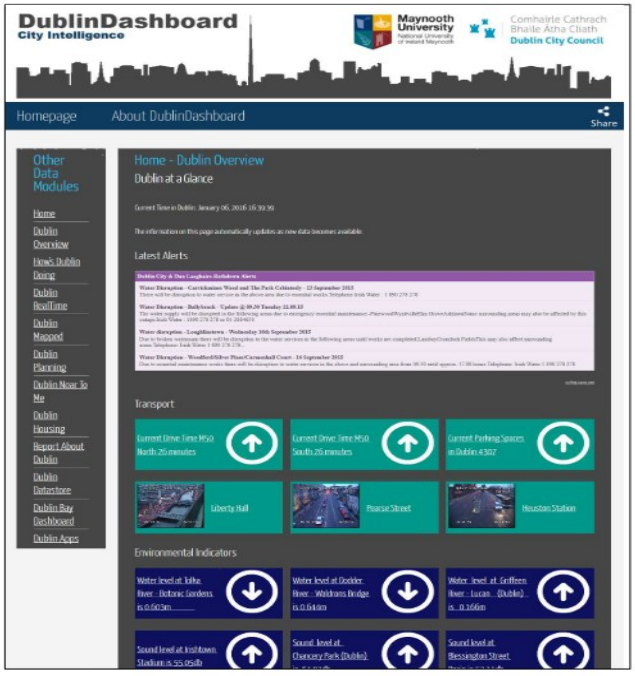

Figure 3- Dublin Overview

From "The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard.", by G.McArdle & R. Kitchin, 2016, *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, III-4/W1(September), 19–25.*

The second module, ***How's Dublin doing ?*** contains links to pre-existing tools related with several fields like cost of living, public local authorities spending, and even benchmark with other cities. However, these links are mixed with two tools specifically created for the Dublin Dashboard: "Dublin Economic Monitor" and "Dublin Indicators".

Figure 4-Time series graph: housing rent in Dublin

From "The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard.", by G.McArdle & R. Kitchin, 2016, *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, III-4/W1(September), 19–25.*

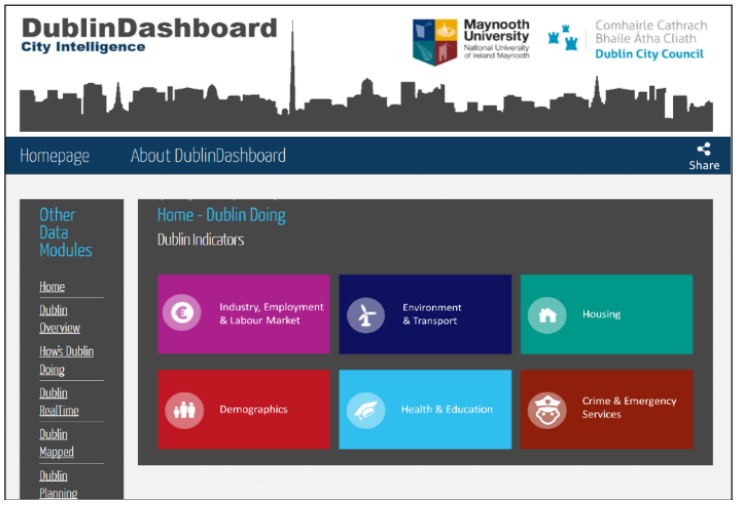

Figure 5- How's Dublin Doing?

From "The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard.", by G.McArdle & R. Kitchin, 2016, *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences,*

"Dublin Indicators" consists in high level indicators in 6 relevant fields for Dublin, namely "Industry, Employment & Labour Market", "Environment & Transport", "Housing", "Demographics", "Health & Education", and "Crime & Emergency Services" as seen in Figure 4. These indicators are time series graphics, and their temporal phase is normally monthly, quarterly, and annually.

These graphs are interactive allowing users to select which data layers should be displayed and to export the graphs as imagens or accessing the data, following an open-source dynamic. Figure 5 shows an example of a time series graphic for average house prices in Dublin.

"Dublin Economic Monitor" shows the quarterly economic reports for the city and its region, consisting in an interactive display of time series graphics as well as gauges indicating their trends and its target values.

The remaining modules aggregate mainly data and links from external projects, who are relevant for the project purpose. Their detailed description is presented in Annex 2.

5.2.3. System Architecture, Data, and Project Reproducibility

Regarding its architecture, the Dublin Dashboard runs on a web application that consists in a series of webpages which display data. This project follows a Model-View-Controller (MVC) architectural pattern, as seen in Figure 6 (McArdle & Kitchin, 2016).

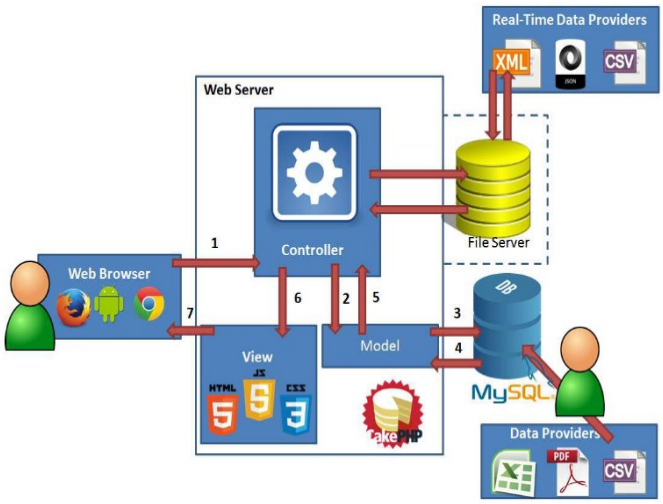

Figure 6- Dublin Dashboard Technologies and Architecture

From "The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard.", by G.McArdle & R. Kitchin, 2016, *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, III-4/W1(September), 19–25.*

Through this model, users interact with the platform via a web browser. The Controller then proceeds to extract the necessary data from the database, proceed with any needed logic through the Model, and then passing the output through the View to be prepared to be displayed on the browser to the user. The process flow is represented by the numbers from 1 to 7.

Regarding data, Dublin dashboard collects it from a variety of sources where data was not collected primarily for the project, which adds great challenges to the project due to different data formats. However, collected data can be divided between real time, which is handled in an automated way and collected through Application Programming Interface (API).

Regarding real time data, Dublin Dashboard uses environmental and traffic data that need high frequency update, often seconds or minutes. Table 5 lists some examples of real time data, its format, and sources. Additionally, to reduce space demand, and following the transparency and open data principle, Dublin Dashboard downloads and stores periodical versions of most recent data, speeding up the process and opening the possibility for future and third parties' analysis.

Table 5- Dublin Dashboard real time indicators example.

From "The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard.", by G.McArdle & R. Kitchin, 2016, *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, III-4/W1(September), 19–25.*

Data Set	**File Type**	**Data Provider**
Air Quality	Api/JSON	Environmental Protection Agency
Ambient Sound Levels	API/JSON	Dublin City Council
River Levels	API/JSON	Office of Public Works
TRIPS Travel Time	CSV	Dublin City Council
Car Parks	XML	Dublin City Council
Traffic Cameras	URL	Dublin City Council

Non real time data are traditionally used to show graphics and indicators in a time series evolution of any parameter, which composes mainly the "Dublin

Indicators" and "Dublin Economic Monitor" tools of the ***How's Dublin doing?*** module. Table 6 lists some examples of non-real time data, their format, and sources. The collection of this data is not automated since their update frequency is low and is fixed in time. This allows the platform developers to upload and treat data within time.

Regarding reproducibility of Dublin Dashboard project, the framework of the project is totally compatible with other cities. The use of free and open-source data, and a system architecture that allowed interoperability of technologies decreases the development costs and ensures that the project becomes affordable and viable. This framework also has the advantage of allowing new data sources that may appear as well as new applications to be added to the Dashboard.

Plus, the project developers draw attention to two key elements that should be performed even before the Dashboard design: assessing the existence of relevant public data sources and the existence of external / internal projects that could be reused, eliminating the waste of work replication.

Table 6- Dublin Dashboard non real time indicators example.

From "The Dublin Dashboard: Design and Development of a Real-Time Analytical Urban Dashboard.", by G.McArdle & R. Kitchin, 2016, *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, III-4/W1(September), 19–25.*

Data Set	File Type	Data Provider
Employment	StatBank/CSV	Central Statistics Office
Gross Value Added	StatBank/CSV	Central Statistics Office
Survey on Income and Living	StatBank/CSV	Central Statistics Office
Overseas Visitors to Dublin	PDF	Failte Ireland
Waste Produced per Capita	PDF	Environmental Protection Agency
Annual Water Consumption	CSV	Dublin City Council
House Unit Completions	Excel	Department of the Environment
Planning and Applications	Excel	Department of the Environment
Population Demographics	StatBank/CSV	Central Statistics Office
Road Fatalities and Injuries	PDF	Road Safety Authority

6. *"Leme. – Sentir o Pulso Económico do Porto"*

6.1. Project Genesis

Porto Municipality Dashboard ideation started middle 2020, as policy makers felt the need of a tool permitting the collection of quality information, namely economic indicators, that could improve decision making. Up until then, the Municipality didn´t possess any simple, fast, and automatic access to key indicators of Porto's economy performance and status.

For that purpose, Porto Municipality, through GIEE, decided to partner with LTP Labs, a specialised consultancy company, in order to develop a **Business Intelligence & Analytics** Project, *"Leme. – Sentir o Pulso Económico do Porto"*.

As stated in the Introduction, this project focus on the economic status:

- Study Porto's attractiveness to national and international investors;
- Analyse the entrepreneurial and business dynamism;
- Get an overview of the economic structure;
- Identify the current human capital, and its potential to propel economic growth;
- Understand the past to better predict the future.

In order to kick off and structure the project, GIEE started by studying and devising the Dashboard composition and purpose. For that, some pre-development steps were performed:

- Identification of relevant internal data sources, trying to avoid waste of resources and duplication of efforts;
- Identification and categorization of relevant external data sources.

6.2. Project Calendar, Preparation and Development

Regarding data sources analysis, GIEE conducted an internal and external research for the best and most relevant indicators that could be helpful in the Dashboard development.

When analysing internal Data sources, the search was not fruitful. Although there are some internal data sources, like MipWeb (https://portalsig.cm-porto.pt/portal/apps/sites/#/mipweb), or GUIA (https://opendata.porto.digital/), none of their indicators possessed any data regarding Porto economy. Hence, performed a search and compilation of relevant external indicators for the project, as well as the description and condition of the data source.

Table 7- Leme Dashboard data sources

Data Source	Conditions	File type	Description
INE	Free	Public Data: API/ JSON Subscription Data: Excel	Provides public and private data; Subscription data provided manually
IEFP	Free	Excel	Provides public data
BPStat	Free	API/ JSON	Provides public data
SIBS Analytics	Paid	Excel- Possibility for API	Provides private data; Provides data in interactive Dashboard or to download

As we can see on table 7, most of the data sources are public and possess free data with API connections, reducing the project costs. The only private data source is SIBS, a multinational Portuguese company holding the largest market share of the payment services market in Portugal. Although paid, SIBS proposed indicators are very insightful when studying and assessing the economic situation of the Municipality. GIEE proceeded with the compilation of all

relevant indicators that could be extracted and incorporated in the Dashboard, presented in the next subchapter.

The project was divided in two main phases. The first, had the duration of 2 months (June-July 2021), aiming to develop version 1.0 of *Leme*, requiring the development of a data aggregation and treatment platform supported and placed in a cloud solution. The second phase, planned to start Q1 2022, consists in the optimization of the platform: development and upgrade of analysis and visualization tools, reorganization and potential increase of the platform size and number of indicators, if needed.

6.3. Dashboard Current Structure and Display: A look at *Leme's* pages and Dataviz and analysis tools

After the creation of Leme 1.0, it is necessary to perform an analysis of the current Dashboard structure and display, in order to create insights to its short term upgrade (mainly during the second phase), **as well as some and future guidance for the platform**.

6.3.1 Dashboard Structure

Version 1.0 of the Dashboard was unveiled on the 29th of July 2021. Entirely in Portuguese, it is divided into 7 Chapters, characterizing 7 main economic areas of Porto Municipality:

- Macroeconomy: an overview of Municipality Macroeconomy;

- Companies: divided in three subfields, Ecosystem, Investment and Finances, aggregates important indicators about Porto economic tissue;

-Tourism: provides a multitude of indicators regarding Porto tourism;

- Housing: provides a detailed overview of Porto Housing situation:

- Talent: divided in three subfields -Education, Employment and Unemployment-, aggregates important indicators of Porto educational and employment status;

- Families: divided in two subfields - Finances and Social-, this field aggregates important indicators about Porto's families economic and social situation;

- ATM Transactions: Aggregating SIBS Analytics indicators, provides information about Porto ATM transactions in number and value.

Overall, more than 80 indicators are distributed through *Leme*. Their names, data source, field, subfield, and periodicity are indicated in table 8 in Annex 4.

All indicators in Leme1.0 are non-real time data, suited for presentation through time series graphics.

The project architecture is presented in figure 7. Like Dublin dashboard, data storage and treatment are performed in a cloud support, in this case through Amazon AWS service. From those databases, that data continuously migrate to Power BI, the business intelligence tool used to create the interactive interface. Leme Dashboard is developed and customized in mobile and web support. This work will perform an analysis to the web version display and development since it is the widely used version.

Figure 7- Leme Dashboard

Regarding data gathering, Excel files and data extraction through API are performed periodically depending on the indicators update by source institutions. Since this 1.0 version doesn't display any real-time data, a continuous data extraction process is not needed, although system architecture possesses that ability.

6.3.2. Dashboard Display

Landing Pages

Regarding Leme's display, the dashboard construction is based on the following visual structure: **Landing Page**, **General Overview Page**, and **Chapter Page**, with the possibility of a **Chapter Landing Page** if the chapter is composed by several subchapters. A detailed description of Leme's display is presented in Annex 3.

Main Maladjustments

Dashboards are useful tools, still they are prone to some problems, namely in the earlier stages of their implementation. Leme is no exception. Common sense and an attentive and proactive management are needed to avoid some maladjustments and to prevent the persistence of others. The highlighted situations are easy to correct if those management principles are followed.

One recurrent maladjustment found throughout the platform ensues from data that do not fulfil all requisites to build the indicators, preventing the disaggregation or benchmark. Since the platform template is programmed to create the same structure, in these cases the variable is displayed with completely blank sectors or incomplete information.

As seen in figure 8, the indicator "Turnover in ICT activities (€)" does not have disaggregation data, originating a completely blank area. A similar situation happens to "Overnight stays(…)" (figure 9) that also lacks data regarding national benchmark, leading to a irrelevant display of the National Benchmark bar chart with only one bar representing the Municipality. Both these situations are recurrent throughout the platform and can create problems to its users when interpreting data.

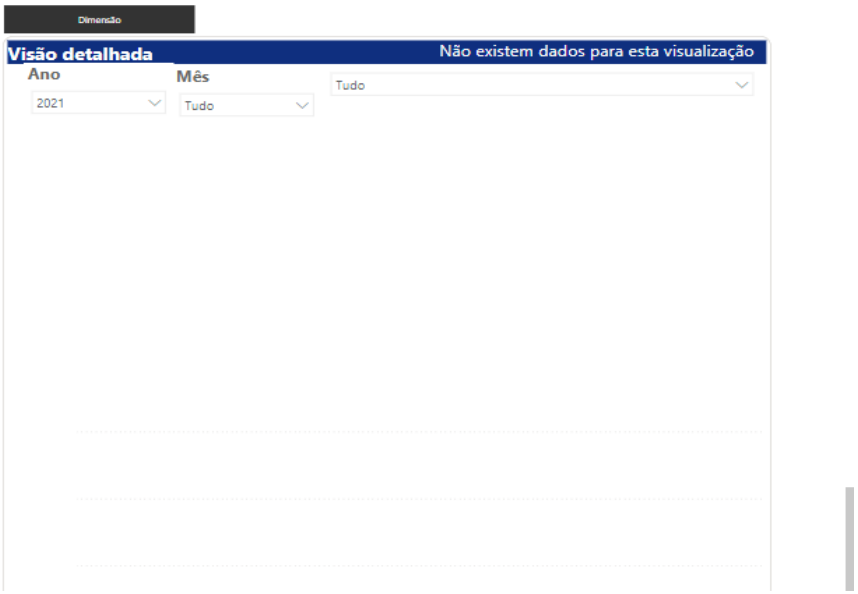

Figure 8- " Turnover in ICT activities(€)" blank Detailed Vision

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

While a completely blank sector does not cause information misinterpretation, it gives the dashboard an unesthetic display, potentially creating a project abandonment feeling. However, regarding the display of incomplete benchmark analysis, the consequences can be even worse, generating information misinterpretation, due to the sole presence of a single bar chart without term of comparison.

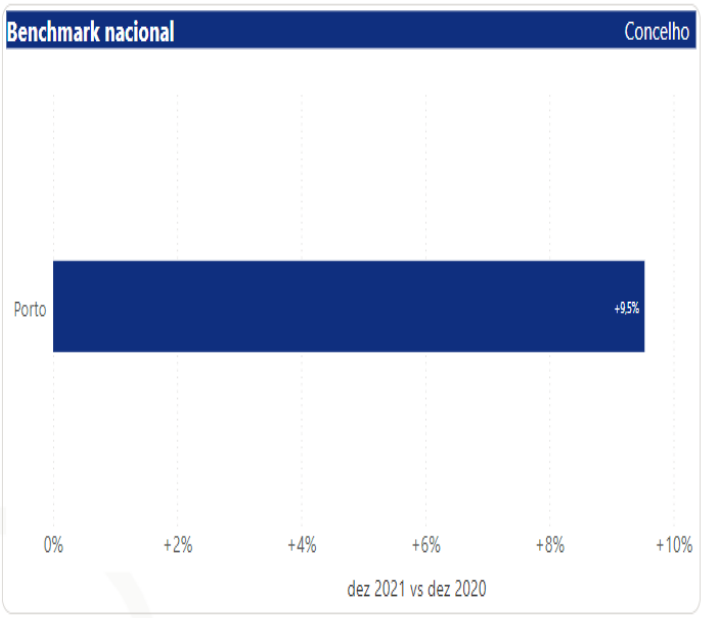

Figure 9- "Overnight stays, by country of residence, in tourist accommodation establishments in the Municipality of Porto" National Benchmark

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

Regarding other maladjustments, some variables have interesting data, but due to a scarce periodicity or even a different nature, in some cases other dataviz graphics options would be more interesting. In some more dangerous cases, the used graphics are wrongly applied.

"Net attraction rate (%) of employed population", a variable inside the Talent chapter, is a case where a small number of historic measures can create a graphic display easy to misinterpret. Looking at figure 10 it is possible to see that due to the linear nature of the graphic, the only two measured values create a big slope between them, leading the user to misinterpret that somehow there was a linear progression between 2018 and 2019. In this case, a bar chart, would be a better alternative, erasing any slope and progressive increase misinterpretation provided by the current graphic.

Figure 10- "Net attraction rate (%) of employed population" Evolution

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

An inadequate representation can be seen when analysing "Average monthly earnings (€) by sector of economic activity and by sex". This variable from the Talent chapter is different from most variables in the dashboard since it represents comparison data instead of cumulative one. As a result, the application of a pie chart as well as a cumulative time series graphic are

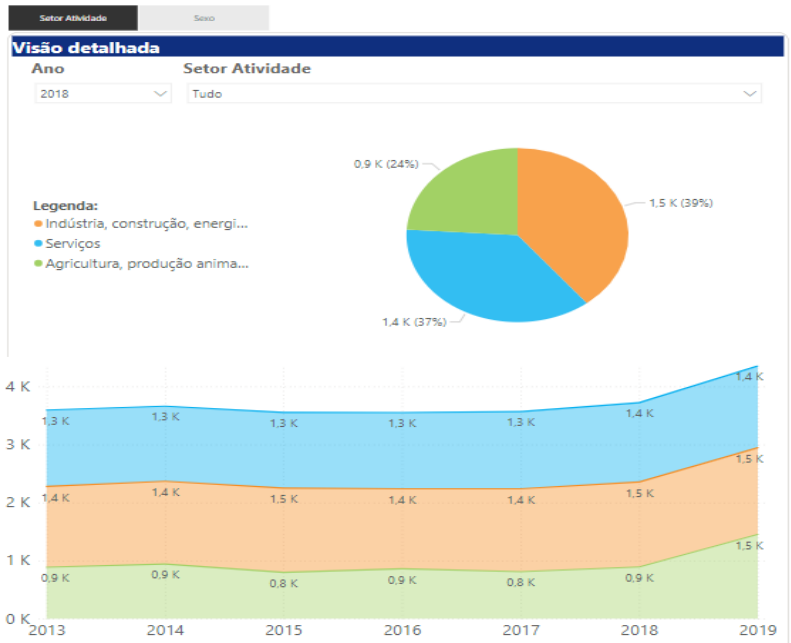

Figure 11- "Average monthly earnings (€) by sector of activity and by sex" Detailed Vision

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-

maladjusted, displaying data as an aggregation, instead of comparing them (figure 11).

In this case, the use of clustered bars could be an easier to interpret alternative. An attentive management of the dashboard is paramount to avoid cases like this.

Another common situation leading to data misinterpretation is the use of inadequate scales to represent quantitative variables. One example occurs with the "Overnight stays (…)" variable. When looking at the disaggregated data display (figure 12), in the cumulative time series graphic, we can see that due to the number magnitude, the yy axis is formatted in a scale that creates a misinterpretation problem, rounding all yy values to 1 million. This situation creates a clear interpreting problem, because only by placing the cursor on the graphic, the user is able to see the real measure.

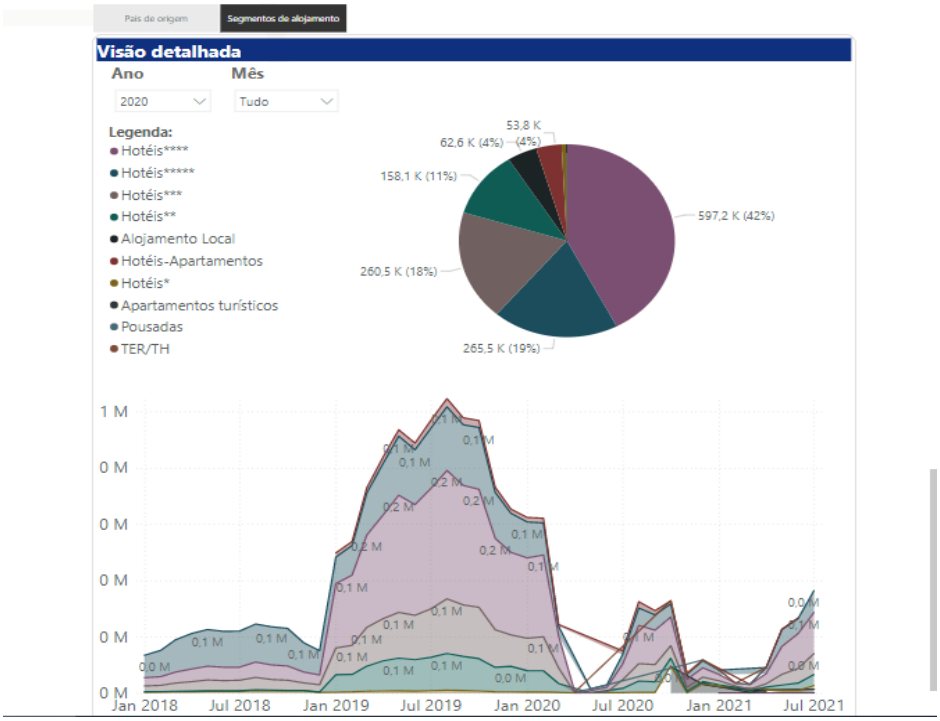

Figure 12- Overnight stays, by country of residence, in tourist accommodation establishments in the Municipality of Porto Detailed Vision

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

Lastly, another situation that can be improved is the existence of obsolete indicators in the dashboard. These variables, although relevant to the project, do not possess up to date measured values and were discontinued. One example is "Proportion of turnover (…)"(figure 13). Discontinued and rarely measured variables, are not interesting for any project of this nature and therefore should be removed from the dashboard.

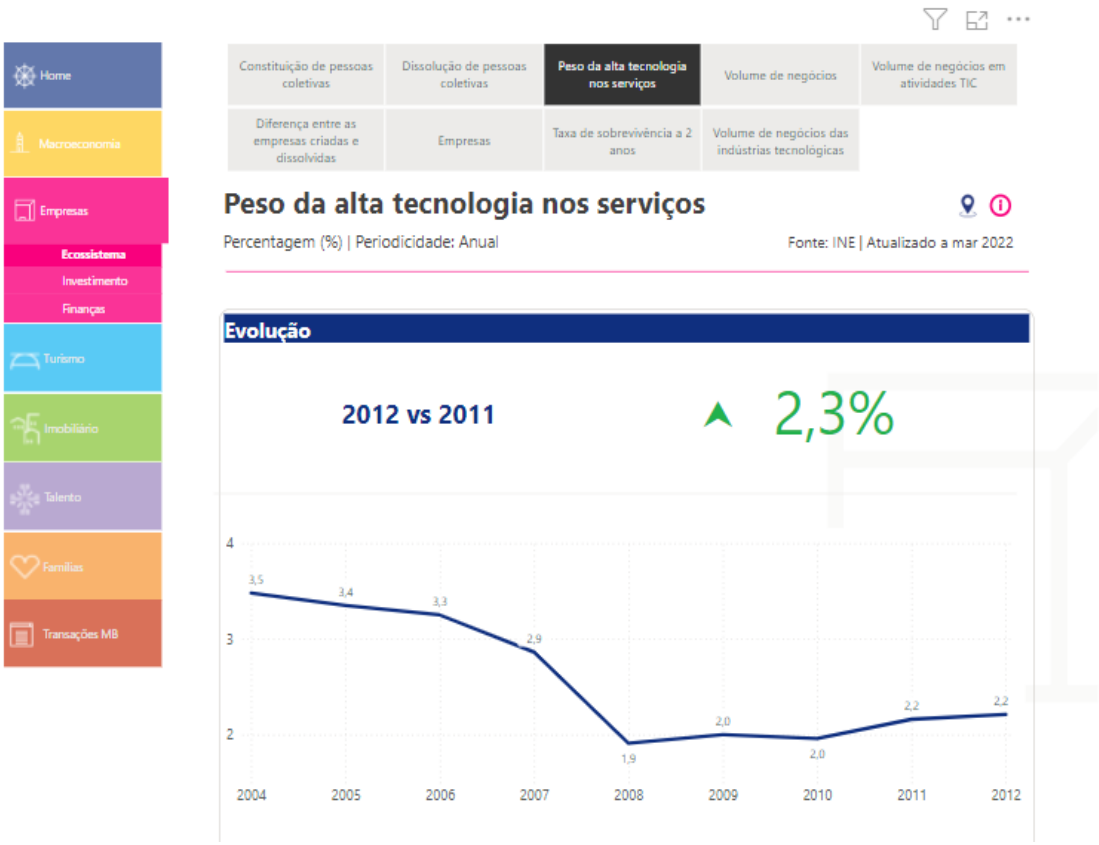

Figure 13"Proportion of turnover in high-technology intensive-knowledge services in total services turnover"

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

6.4. Short term objectives: Getting Leme ready

According to our literature review, to fully enjoy the possible benefits for Public Dashboards, thus increasing transparency, accountability, and disclosing relevant information to people and increase policy making quality, the short-term goal for *Leme*, is to structurally upgrade the platform, eliminating non-interesting or obsolete indicators, and potentially adding new and relevant ones, exploring the full potential of Microsoft Power BI (Becker & Gould, 2019; Hall et al., 2000). This step is already outlined in the second phase of the project.

Looking at structural changes, the main step forward is the individualization of each indicator. This step will allow the platform developers to customise the templates to each indicator, avoiding using a unique model. Therefore, each variable needs to be analysed regarding its main characteristics and available information, to then choose the best Dataviz and analysis tools to be applied. This step is essential to decrease the risk of wrong interpretation of information and reduced transparency that could lead to scarce usage of the platform (Matheus et al., 2020).

Another important factor to be considered is data anonymization. Data protection is an essential requirement for public dashboard design (Kitchin et al., 2015), and further potential data sources and indicators should be evaluated under this scope, to avoid any legal issues that may appear due to privacy breach (Matheus et al., 2020)

This step is of huge importance for the platform improvement, allowing to correct all the aforementioned maladjustments, and making *Leme 2.0* an even more user friendly and easy to interpret platform to "feel the economic pulse in Porto".

6.5. Dashboard for the future: How Leme can propel Porto to become smarter

After the conclusion of the second phase, *Leme 2.0* will reach a stage where its public relevance could increase, fostering communication and public involvement (Berntzen et al., 2018). As seen through our literature review on smart cities, and looking at Dublin´s Dashboard, the opportunity for Porto to improve its status as a smart city is unique.

While the primary objective of this project is to create a platform to collect and display economic information about the municipality, nowadays, metropolitan and developed cities are creating information and communication platforms with instrumental and important data to communicate with its citizens (IBM Global Business Partners, 2009). Those platforms aggregate and display relevant data, whether it is information about municipalities economic and social status, or real time data with daily base relevant information. Dublin Dashboard is a great example of such platforms (McArdle & Kitchin, 2016).

Leme is a very well structured and important dashboard , that can become the reference project for further developments in collecting and displaying other types of information, including real time data.

The possibility to integrate *Leme* in a web-based solution, like Dublin Dashboard, where Porto Municipality could display economic and social data, as well as traffic/transportation and environmental data is real(McArdle & Kitchin, 2016). Using this platform as a reference project to the future, is fundamental to bring Porto to the top tier of smart cities in the World, bringing Porto to the leadership of digital transformation in Portugal.

It is also relevant to mention, that while *Leme* aggregates only non-real time economic and social data, the Municipality already possesses several

interesting projects in several webpages, developed by other departments within its structure that are of interest to integrate such a platform. Such as Dublin Dashboard, due to the different development architecture, it may not be immediately possible to integrate such different projects in the same web-based application (McArdle & Kitchin, 2016). However, there also the possibility to supply links leading to those platforms, using the platform as a guide and reference tool for citizens and its users to find relevant information. Some examples of potential developed projects that could further integrate the proposed solution are MipWeb (https://portalsig.cm-porto.pt/portal/apps/sites/#/mipweb), a webpage with the collection of relevant maps for Porto, or GUIA (https://opendata.porto.digital/), the municipal open data portal.

Another important benefit of such proposed solution is that, turning this platform in the reference for future relevant projects, Porto Municipality would also be guaranteeing that those developments would be architecturally similar, allowing compatibility between them, further increasing the integration and the quality of their public service (Al Nuaimi et al., 2015; IBM Global Business Partners, 2009; Matheus et al., 2020; McArdle & Kitchin, 2016).

Conclusions and Further Developments

This study intends to demonstrate that it is possible for Porto City Council to develop a Business Intelligence platform, a Dashboard, that could propel its vision of making Porto a smarter city. The set of public data available, constitutes the necessary basis to build such a project. The usage of Microsoft Power BI software to develop such tool, seems a good choice, since it is a versatile software, and allows developers to customize the platform and their indicators according to the project objectives.

However, we try to demonstrate that the project can be improved. Currently, the Dashboard displays all its indicators through the same template, creating maladjustments to several variables. The different nature and availability of data would require an individual treatment and customization. Therefore, the next step needs to be focused specifically on the individualization of indicators and their customization, increasing the clarity and utility of information. This way, following the mantra of the Dublin Dashboard creators, McArdle & Kitchin, 2016, "the cognitive load required to understand each indicator, needs to be low", facilitating the accomplishment of the final objective: to become publicly available to all citizens.

When it comes to the quantity and quality of the platform indicators, Leme Dashboard already scores fairly well. Therefore, we argue that the primary focus should be improving the clarity of information, followed by the search for more indicators and/or data sources, a necessary step in the improvement of the project.

Finally, this platform should aim to be shared publicly through a web page application. We argue that, to pursue the globalisation of information and increase Porto Municipality competitiveness, this project, should become the core reference for further developments regarding data collection and information to

the public. This way, the City Council would be guaranteeing that further projects obey the same architecture, and would ultimately be displayed on the same platform, avoiding information dispersion through the web, increasing proximity an simple access to its citizens, improving their message and public service.

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Annexes

Annex 1

2.1.6.2. Data cycle for public dashboards

The first flow (F1) depicts the data collection by the public organization. This data can have many formats and origins, coming from sensors, public and private institutions, and citizens.

In stage 2, data is processed. This is an essential part of the procedure, since it is here that the input data is processed and prepared for analysis and visualization. Apart from the cleaning and preparation of data, a crucial step is also performed in stage 2, database separation. The authors propose the division of a database in Public Private Data (PPD), data that can't be shared externally due to legal, confidentiality, and strategic reasons; and Public Open Data (POD),all data that is selected to be shared with the public. Much of the data overlap, although the PPD needs to be normalized and standardized to become POD, in a process the authors call "anonymization".

Stage 3 comprises data analysis. In this step, data goes through a process of big data analytics, being subject to statistical analysis, either manually by data scientists or through automatic data analysis processes.

The next step is data visualization. It is here that the data are combined an organised visually in dashboards. Depending on the data, dashboard should be different, thus resulting in internal dashboards for public servants and politicians using PPD and public dashboards using POD, that could be displayed in the streets or through other supports like private smartphones or computers.

The final step is data usage. In this step, data is then used by internal players and decision makers, or by the community. This way, information

asymmetry between citizens and public institutions is reduced, and civil servants improve their decision making by enlightening them with better information and sophisticated data analysis tools.

Finally, the authors close the cycle by connecting step 5 again to step 1, data collection. This indicates their intention in stating that a Business Intelligence system like this needs continuous update, since the decisions that public servants and citizens take using the available dashboards may have immediate impact on future data inputs, whether they are measured in real time or medium to long time.

Annex 2

2.2.2. Dublin Dashboard: Composition

Real-Time Dublin module contains mainly real-time data tools in 2 specific fields: transport and environment. Two real-time interactive maps are displayed allowing users to zoom in and out and click some interesting features with additional information: "Real-Time Transport Map" and "Real-Time Environment Map". "Real-Time Transport Map" shows information for the location of main roads segments, car parks, Dublin bike stations and traffic cameras. Interactivity allows the user to select each feature and extract information, for example the number of free parking space for a specific car park and time. Similarly, "Real-Time Environment Map" also shows an interactive map with information and location for different sound, weather, air quality or water sensors. Additionally, this module provides links to other real time services for Dublin developed by other institutions.

Dublin Mapped, like Real-Time Module, shows interactive maps with data collected in the last Irish Censuses, allowing the user to see relevant census data at micro area levels. Although developed for other projects, these maps were adapted to Dublin Dashboard.

Dublin Planning, Dublin Housing, Dublin Near to Me and Dublin Reporting modules mainly provide links to other services. Developed for other projects, were found by Dublin Dashboard authors when performing an inquiry about external relevant applications for Dublin. Although much of the data behind these services is public, it became evident that such powerful tools should be used, avoiding the expense of redeveloping specific tools for the same data analysis.

Dublin Data Stores and Dublin Apps modules also provide Dublin Dashboard users with links for external platforms with relevant data about the city. However, differently from other modules, ***Dublin Data Stores*** provides links for other websites and platforms with open source data, some of which are used to create Dublin Dashboard tools, while ***Dublin Apps*** provides links to download mobile applications with relevant data about Dublin.

Dublin Bay Dashboard is a very specific module for Dublin Bay area developed as part of another European funded project. This module provides access to relevant data about environment and port activity in Dublin Bay, as well as access to interactive maps with relevant information like showing real time ship movements.

Annex 3

3.2.1.2 Dashboard Display

Landing Pages

Regarding the visual appearance of the Dashboard, the **Landing Page** is an intuitive and suggestive interface, that follows the project theme (figure 14).

The simple but suggestive design is also interactive. It is possible to see a rudder design in the centre, as well as intuitive pictures for each one of the 7 chapters that compose this platform. These figures are interactive: by clicking them, the user is provided with a direct path to the respective chapter. Alternatively, when clicking the central rudder, the user is transported to the **General Overview Page**. Another interesting feature is the doubts/suggestion form accessible through the exclamation mark on the bottom right corner of the page.

Figure 14- Leme Landing Page

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

The **General Overview Page,** seen in the figure 15, is the first Dashboard page where the user is presented with relevant information. In this page, the user

has access again to the 7 main chapters, as well as their respective design figures. The difference when compared to the **Landing Page**, consists in the presentation of two selected relevant indicators for each Chapter. In this page, although schematically, the Dashboard already provides a KPI measure, in the form of a green/red arrow, representing the most recent variation for the variable. Alongside that information, the user can already see each indicator data source as well as the latest update and information date. Like the previous **Landing Page**, it is through the chapter icons that the user can navigate to each independent Chapter.

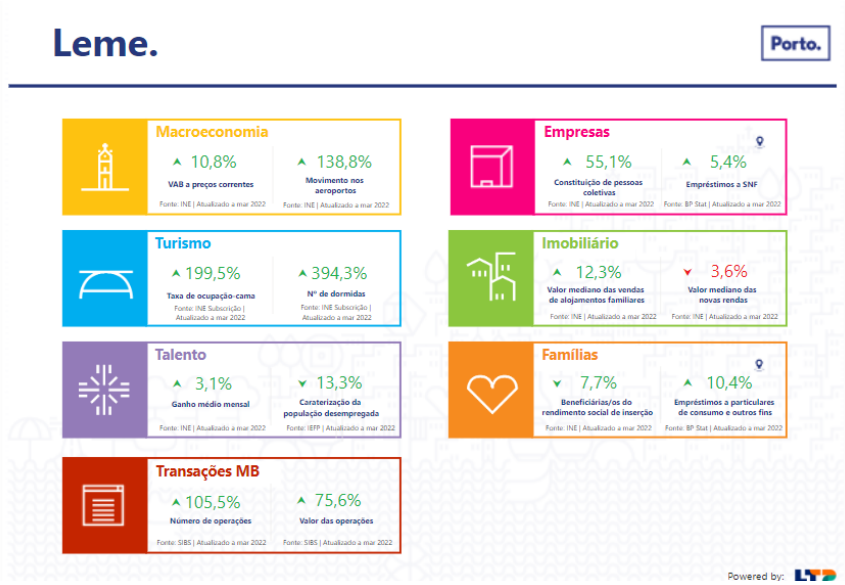

Figure 15- Leme General Overview

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

When choosing a particular Chapter, the user may be presented with a **Chapter Landing Page,** if the chapter is subdivided in two or more subchapters. Figure 16 shows the example of Talent chapter, and its **Chapter Landing Page**. In here, the same structure logic is applied as in the **General Overview Page,** since the user is presented with banners for the respective subchapter, each one with two relevant indicators displayed in the same logic as before, displaying the KPI variation in the same form of red/green arrow, and also showing the last measured value.

From here, the user selects the respective chapter/subchapter, where all the indicators are displayed, and where *Leme* displays its data visualization and analysis tools.

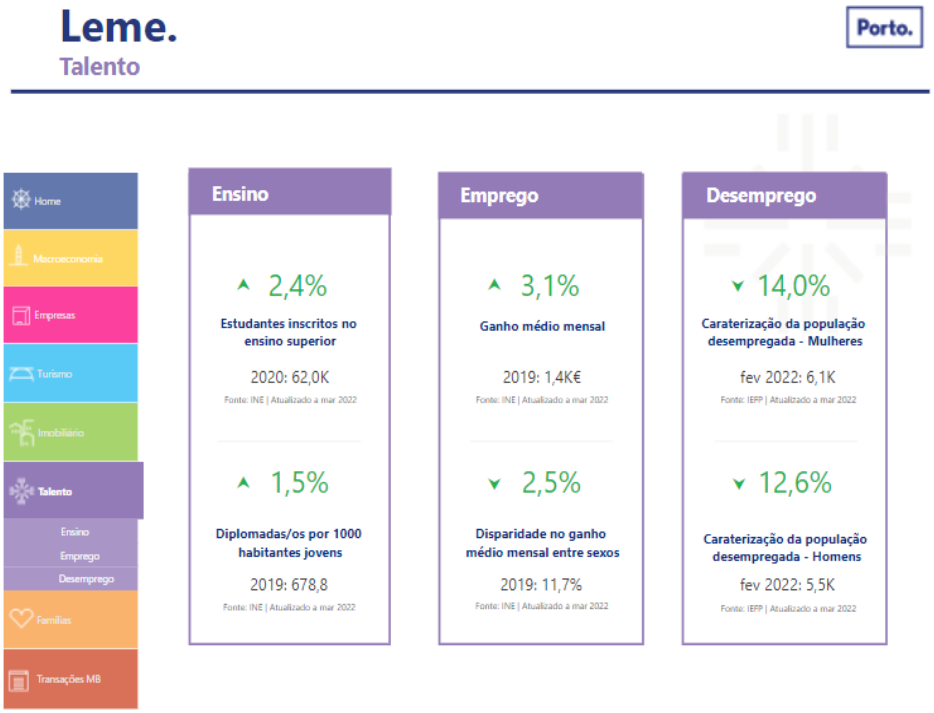

Figure 16- Talent chapter Landing Page

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

Variable Pages

Regarding variable pages, version 1.0 of Leme is built around a template applied to all variables. This means that all indicators in the platform are shown using the same Dataviz and analytic tools, in a logic of "applying the same recipe" to all indicators.

To better understand this template, and how it fits the diversity of indicators present in the platform, this work will perform a brief analysis to the template structure also presenting some of the most frequent maladjustments to certain type of variables.

Starting with the template structure, a well-adjusted variable example is the "Exports of goods (€)", placed inside the Macroeconomy chapter. This variable is a non-real time variable, provided monthly by INE, measuring the exports of Porto Municipality in euros. Analysing figure 17, the top section of this variable dataviz is displayed. Here we can see all markers for all variables inside the variable respective chapter/subchapter. Next, the user is presented with the variable title, as well as its measure units, periodicity, data source and variable latest update (which reflects last time that the platform was updated and should

Figure 17- Exports of goods(€) top section

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

not be confused with the last available measure for the variable). Also, on the top banner, there is an information hyperlink to the data source.

Further down in the same page (figure 18), the user is presented with the first Dataviz tools from the template, starting with the latest measured value and a KPI showing the homologous variation on a yearly base. Below this information, in a section called Evolution, the user is presented with the graphic linear display of all historical measured values for the respective indicator. This simple graphic is interactive, allowing the user to select/place the mouse on top

of any value, automatically filtering the next results, and allowing a small pop-up window with more relevant information. Below the time series graph, the template displays the homologous variation graphic, informing the user about tendencies relatively to the previous year.

Figure 18- Exports of goods (€) Evolution

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

Below, the example of a second section- National Benchmark – is shown (figure 19). The template displays a horizontal bar chart, allowing the comparison with the last homologous variation for Porto's Municipality with the equivalent for every major Portuguese county.

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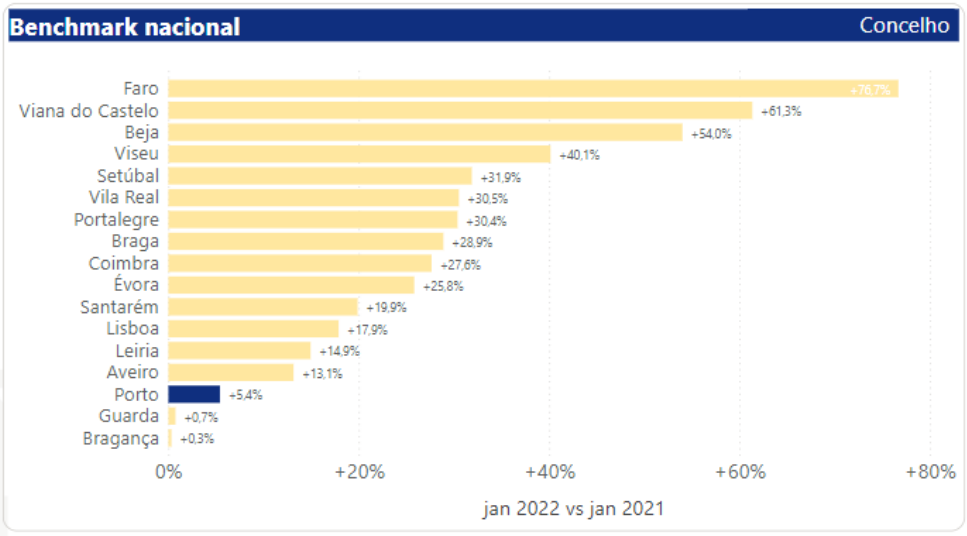

Figure 19-Leme National Benchmark section

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

The last section of the Dataviz template is called Detailed Vision, seen in figure 19. In here some additional information that the variable may have, is disaggregated, and displayed through a pie chart as well as a cumulative time series chart. For the studied example, two forms of disaggregation are possible, through the type of good exported, or through the type of market (intra-EU vs extra-EU), as seen in figure 20. Overall, all variables presented in Leme are subject to this template and are displayed according to this structure.

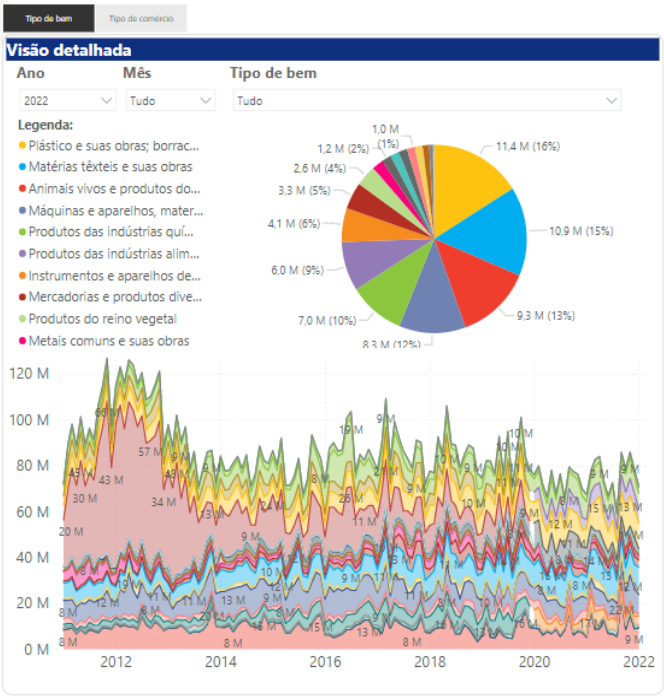

Figure 20- Exports of goods Detailed Vision: type of product

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

However, since not all variables possess the necessary information to fulfil all requisites for this display structure, several maladjustments appear throughout the platform, as well as some other design errors that can create confusion to the platform users. Although there is a significant number of improvements to be made, this work will review some of the most important and prominent maladjustments present throughout this 1.0 version.

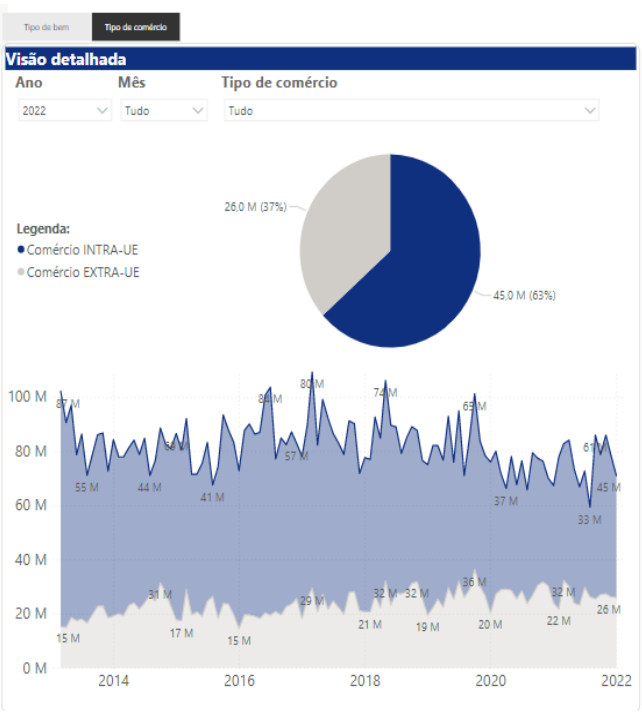

Figure 21- Exports of goods Detailed vision: type of market

Source: https://app.powerbi.com/groups/me/reports/de1c0a93-4fb3-4a10-a70c-21a93b95b011/ReportSection49a2a646d40c4c7133ed

Annex 4

Table 8- Leme Dashboard indicators

VARIABLE	CATEGORY	SUBCATEGORY	DATA SOURCE	FREQUENCY	DISAGGREGATION
GVA at current prices and by industry	Macroeconomics	N/A	INE	Yearly	Municipality
Average annual resident population	Macroeconomics	N/A	INE	Yearly	Municipality
Imports of goods (total and by sector)	Macroeconomics	N/A	INE	Monthly	Municipality
Exports of goods (total and by sector)	Macroeconomics	N/A	INE	Monthly	Municipality
Passengers boarding at airports	Macroeconomics	N/A	INE	Monthly	Municipality
Passengers disembarking at airports	Macroeconomics	N/A	INE	Monthly	Municipality
Turnover by sector	Companies	Ecossystem	INE	Yearly	Municipality
Turnover of high and medium technology industries	Companies	Ecossystem	INE	Yearly	AM Porto
Turnover in ICT activities	Companies	Ecossystem	INE	Yearly	AM Porto
Proportion of turnover in high-technology intensive-knowledge services in total services turnover	Companies	Ecossystem	INE	Yearly	AM Porto
Companies by size	Companies	Ecossystem	INE	Yearly	Municipality
Constitution and dissolution of legal persons, by sector of activity	Companies	Ecossystem	INE	Monthly	Municipality
Gross Formation of Fixed Capital	Companies	Investment	INE	Yearly	AM Porto
Investment Fee	Companies	Investment	INE	Yearly	AM Porto
Average expenditure on R&D in institutions and companies with research and development	Companies	Investment	INE	Yearly	AM Porto
2 year survival rate	Companies	Ecossystem	INE	Yearly	Municipality
Overdue loans to SNF (% debtors)	Companies	Finances	BP Stat	Monthly	AM Porto
Overdue loans to SNF (Million €)	Companies	Finances	BP Stat	Monthly	AM Porto
Loans to SNF (Million €)	Companies	Finances	BP Stat	Monthly	AM Porto
NFC overdue loans ratio	Companies	Finances	BP Stat	Monthly	AM Porto
Loans to SNF (Thousands debtors)	Companies	Finances	BP Stat	Monthly	AM Porto
Average habitable surface of licensed divisions in new constructions for family housing	Housing	N/A	INE	Yearly	Municipality
Number of buildings completed by type and work destination	Housing	N/A	INE	Yearly	Municipality
Median value of bank appraisal, per m2	Housing	N/A	INE	Monthly	Municipality
Average value of buildings transacted	Housing	N/A	INE	Yearly	Municipality
Purchase and sale contracts (No.) of buildings Type of building	Housing	N/A	INE	Monthly	Municipality
Median sales value per m2 of family accommodation	Housing	N/A	INE	Quarterly	Municipality
Median value of rents, per m2, in new leases	Housing	N/A	INE	Semiannual	Parish
New rental agreements for family accommodation in the last 12 months	Housing	N/A	INE	Semiannual	Parish
Higher education enrollment rate	Talent	Education	INE	Yearly	Municipality
Number of students enrolled in higher education, by year and by nationality	Talent	Education	INE	Yearly	Municipality

Higher education graduates per 1000 inhabitants of the resident population aged between 20 and 29 years	Talent	Education	INE	Yearly	Municipality
Higher education graduates in S&T areas per 1000 inhabitants of the resident population aged between 20 and 29 years	Talent	Education	INE	Yearly	Municipality
Institutions of higher education by institutional nature	Talent	Education	INE	Yearly	Municipality
Personnel at the service of companies by economic activity	Talent	Employment	INE	Yearly	Municipality
Employed population by occupation	Talent	Employment	INE	Yearly	Municipality
Employed population by sector of economic activity and sex	Talent	Employment	INE	Yearly	Municipality
Proportion of employed population in establishments with less than 10 workers	Talent	Employment	INE	Yearly	Municipality
Employed population by level of education	Talent	Employment	INE	Yearly	Municipality
Proportion of employed population with higher education	Talent	Employment	INE	Yearly	Municipality
Proportion of employed population that changed companies in relation to total employment	Talent	Employment	INE	Yearly	Municipality
Net attraction rate (%) of employed population	Talent	Employment	INE	Yearly	Municipality
Average monthly earnings (€) by sector of economic activity and by sex	Talent	Employment	INE	Yearly	Municipality
Disparity in average monthly earnings between levels of qualification of the employed population	Talent	Employment	INE	Yearly	Municipality
Disparity in average monthly earnings between sectors of activity of the employed population	Talent	Employment	INE	Yearly	Municipality
Disparity in average monthly earnings between the sexes of the employed population	Talent	Employment	INE	Yearly	Municipality
Gini coefficient of declared gross income deducted from the IRS settled by tax aggregate	Talent	Employment	INE	Yearly	Municipality
Characterization of the unemployed population by qualifications	Talent	Unemployment	IEFP	Monthly	Municipality
Characterization of the unemployed population by age group	Talent	Unemployment	IEFP	Monthly	Municipality
Characterization of the unemployed population by sex	Talent	Unemployment	IEFP	Monthly	Municipality
Characterization of the unemployed population by time of enrollment	Talent	Unemployment	IEFP	Monthly	Municipality
Bed occupancy rate in tourist accommodation establishments in the Municipality of Porto	Tourism	N/A	INE subscription	Monthly	Municipality
RevPAR of tourist accommodation establishments in the Municipality of Porto	Tourism	N/A	INE subscription	Monthly	Municipality
Rooms in tourist accommodation establishments in the Municipality of Porto	Tourism	N/A	INE subscription	Monthly	Municipality
Accommodation capacity in hotel establishments in the Municipality of Porto	Tourism	N/A	INE subscription	Monthly	Municipality
Average stay (No.) in tourist accommodation establishments in the Municipality of Porto	Tourism	N/A	INE subscription	Monthly	Municipality

Guests, by country of residence, in tourist accommodation establishments in the Municipality of Porto	Tourism	N/A	INE subscription	Monthly	Municipality
Overnight stays, by country of residence, in tourist accommodation establishments in the Municipality of Porto	Tourism	N/A	INE subscription	Monthly	Municipality
Foreign museum visitors	Tourism	N/A	INE	Yearly	Municipality
Museum visitors by geographic location	Tourism	N/A	INE	Yearly	Municipality
Tourist accommodation establishments, by type	Tourism	N/A	INE	Yearly	Municipality
Ratio of overdue loans to individuals	Families	Finances	BP Stat	Monthly	AM Porto
Loans to individuals (Thousands debtors)	Families	Finances	BP Stat	Monthly	AM Porto
Overdue loans from individuals (% debtors)	Families	Finances	BP Stat	Monthly	AM Porto
Overdue loans from private individuals (Millions of €)	Families	Finances	BP Stat	Monthly	AM Porto
Loans to individuals (Millions of €)	Families	Finances	BP Stat	Monthly	AM Porto
Ratio overdue loans to households for consumption and other purposes	Families	Finances	BP Stat	Monthly	AM Porto
Loans to individuals for consumption and other purposes (Thousands debtors)	Families	Finances	BP Stat	Monthly	AM Porto
Overdue loans to individuals for Consumer and other purposes (Millions of €)	Families	Finances	BP Stat	Monthly	AM Porto
Loans to individuals for consumption and other purposes (Millions of €)	Families	Finances	BP Stat	Monthly	AM Porto
Interest rate on home loans to individuals	Families	Finances	BP Stat	Monthly	AM Porto
Housing loans to individuals (Millions of €)	Families	Finances	BP Stat	Monthly	AM Porto
Housing loans to individuals (Thousands debtors)	Families	Finances	BP Stat	Monthly	AM Porto
Ratio overdue housing loans to individuals	Families	Finances	BP Stat	Monthly	AM Porto
Overdue home loans from private individuals (Millions of €)	Families	Finances	BP Stat	Monthly	AM Porto
Mortgage credit granted to individuals per inhabitant	Families	Finances	INE	Monthly	Municipality
Beneficiaries of social insertion income, social security by place of residence and age group	Families	Social	INE	Yearly	Municipality
Processed amount of social income from social security insertion by place of residence	Families	Social	INE	Yearly	Municipality
Beneficiaries of social insertion income, social security per 1000 inhabitants of working age	Families	Social	INE	Yearly	Municipality