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INNOVATION KPIs TO FOSTER INNOVATION AND OPERATIONS ALIGNMENT

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Abstract: The present thesis explores the criticalness of innovation metrics in companies, working alongside Portugal Technology Solutions (PTS)[1]. This study proposes an innovation monitoring system to bridge the divide between innovation and operations by developing KPIs geared to capture the former. To ascertain this, the study incorporates the innovation KPIs framework proposed by Zhen et al. (2009) into a survey for the company's managers and specialists. The report also emphasises the possibility of transposal of the applied methods to implement innovation KPIs to achieve organisational alignment in similar technological and disruptive businesses.

Keywords: innovation, innovation metrics, KPIs implementation, innovation-operational alignment, organisational alignment.

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[1] Under confidentiality issues, information such as the name of the company and its departments have been changed. The company will be referred to as Portugal Technology Solutions (PTS). In in-text citations and bibliography entries, references to the company were replaced by "___".

1. Introduction

Innovation is critical for surviving and succeeding in a quickly changing corporate landscape (Tohidi and Jabbari 2012). Businesses, driven by the need to provide outstanding products and services, stand apart from their rivals through disruptive solutions. This process starts with creative ideas, opening doors to higher productivity levels, job creation, and better public image, while enabling the companies to become more adaptable and incentivising development ("Creativity and Innovation Management: How to Inspire Original Ideas," n.d.). Consequently, innovation is already perceived as a top priority by around 80% of businesses, and 66% plan to increase spending in this objective shift ("Nearly 80% of Companies Worldwide Rank Innovation as a Top-Three Priority for 2023" 2023).

Risk in an innovative strategy can lead to many positive outcomes (Tan 2007). Firstly, it leads to competitive advantages by assisting businesses in setting themselves apart from rivals, gaining market share and revenues, through staying relevant in quickly changing sectors. Simultaneously, it allows the company to be cost-efficient by simplifying processes, lowering costs, and using resources more wisely.

Secondly, it contributes to long-term viability, by fostering technical improvements that contribute to increased adaptability to shifting customer preferences, bringing about higher customer satisfaction, as well as loyalty and word of mouth (Tai, Wang, and Luo 2021). It also plays a part in attracting and retaining talent, since it contributes to personal and professional growth within the companies' personnel.

Lastly, according to Du, Zhu, and Li (2022), innovation is even a tool to expand globally, helping businesses go beyond their immediate markets and access new consumer bases, become more sustainable and comply with regulations by developing friendly practices and minimising the environmental impact.

However, innovation can also be a synonym for difficulties when handled improperly. According to Malakar (2023), innovation mismanagement may lead to increasing turnover, an inability to compete and a deteriorated reputation. The uncertainty that comes with disruption, individuals' concerns about judgement, and the likelihood of negative consequences considerably restrain the innovative aptitude in an organisation. Therefore, firms must manage innovation effectively to harness possible advantages while mitigating the corresponding risks.

Key Performance Indicators (KPIs) are performance metrics and one method through which firms may manage innovation more efficiently (Velimirovic, Velimirovic, and Stankovic 2011). These tools assess the effectiveness of policies and practices designed to improve a company's performance. They set strategic direction, namely by evaluating investments, resource allocation, manager responsibility and performance, being essential for identifying subpar work and taking corrective steps to make improvements (Godener and Soderquist 2004).

Based on Ryu, Lee, and Choi (2015), and their argumentation that innovation KPIs may be used to synchronise all firm departments, particularly the operational and inventive ones, the use of innovation KPIs as tools for a firm's innovation-operational alignment will be the main topic of this thesis. The goal is to provide an in-depth exploration of how these KPIs can be harnessed to promote said alignment.

For this, the study will take place within the framework of Portugal Technology Solutions (PTS), a private and independent technological organisation present in more than 40 countries (in the EU, Eastern Europe, Africa, the Americas, and Asia), which provides inspection services, testing, training, and technical consulting services (___ Group 2016). Being part of an international Group, the focus of the study will be only on Portugal.

Specifically, this study's main question is: "What are the critical KPIs to implement and how can they be effectively derived from the diagnosis of the company's innovation level to

contribute to the company's organisational alignment?". The point of this study is to learn which KPIs may be implemented in the company context to reach out to this alignment. The important findings may improve innovation management knowledge and offer useful tactics for companies looking to innovate their way to operational dominance.

The following chapters will include four main sections. The literature review focuses on previous research on innovation KPIs, innovation management and operational alignment, by exploring theoretical frameworks as the basis for the investigation. Further on, the research conducted will rely on data collection and analysis of a survey to understand the priority and how to track innovation in PTS. The findings and discussion will lead to a debate and comparison of the results with the literature, followed by the KPIs proposal and suggested directions for future research.

2. Literature review

a. Different types of Innovation

Innovation in an organisation is the process of developing and putting into use new concepts, ideas, goods, services, procedures, or business models to promote growth, enhance productivity, and maintain market competitiveness, coming up with creative solutions for current problems (Kogabayev and Maziliauskas 2017). Thus, innovation should be a priority for any organisation (Tohidi and Jabbari 2012), and it is indispensable that any manager is aware of the different forms it takes.

Innovation is a many-sided concept that englobes product, process, and organisational innovation. Varadarajan (2018) and Demircioglu, Audretsch, and Slaper (2019) define Product Innovation as the upgrades of already existing products, guided mainly by customer demands and technical improvements so that the business fulfils changing client preferences and remains competitive. The authors use the term Process Innovation to refer to adjustments made to the steps of production, pushed by the aim to boost efficiency and cut down costs. When discussing

Organisational Innovation, they mention the development or modification of internal company procedures (such as operational and workplace design) that can contribute to productivity and profitability improvements, reduced costs or reinforced brand recognition.

In other words, the urge to innovate may lead to changes in the products, processes, structure, management, and stakeholders. Thus, these types may be taken into consideration when evaluating the implementation of KPIs to anticipate possible innovative shifts in a company

b. Previous research on Innovation Metrics

Understandably, innovation is perceived as a critical success factor among businesses. But will this trend also be reflected in the approach to innovation measurement frames? According to Capozzi, Gregg, and Howe (2010), though 75% of business leaders classify innovation as a priority, only 20% actively keep track of it through formal metrics that empower the company to track the performance in the area, which reflects a clear gap and an opportunity for businesses to improve. This being the case, it is necessary to comprehend how to come up with measurement systems to overcome the lack of control of activities in any company.

Innovation metrics, like any other objectives traced by a company, must be SMART ones: Specific, Measurable, Attainable, Relevant and Time-bound (Bjerke and Renger 2017). Around 70% of large private companies achieved performance success using this standard in their daily objectives (Ishak, Fong, and Shin 2019), which means that harnessing metrics with these properties is valuable for companies.

Lakiza (2018) summarized the characteristics every measurement system that ambitions to be effective in flourishing innovation should have. The author defended it should promote self-initiative among the employees to be dynamic, emphasising intangible elements (such as employee motivation and customer satisfaction) in a flexible and adaptable system. The main

focus must be on the goals to have a motivating purpose based on a shared ambition, prioritising the future over past actions (Appendix 1).

Dewangan and Godse (2014) suggest five guiding concepts for a successful performance measurement programme. They define they must be as extensive as possible by being multi-dimensional and evaluating distinct stages of the innovation cycle, incentivising collaboration and ensuring full comprehension of the phenomena. They also have to attend to the objectives of organisational stakeholders to ensure alignment, focus and clearness, and encourage a cause-and-effect connection, all of these aggregated on simple and easily implemented, evaluated and adjusted metrics. (Appendix 2).

This way, a flow can be traced to ensure all the steps are considered. Deschamps and Lakiza (2018) explored these stages (Appendix 3) defining the starting point as the collection of information from the literature and stakeholders to comprehend the context and tools. Then, a hypothesis can be created and applied in the form of a KPI proposal. Over time, the hypothesis has to be assessed through feedback. After this, adjustments must be made to achieve a Final KPI Proposal that will have to be evaluated once more. Note, however, that provided the ever-changing context of any business enterprise, this proposal must be revisited regularly. This development of innovation KPIs must be gradual, which is essential to ensure that the right choice, both in terms of timing and the nature of the KPI itself, is made. This will prevent the company from having excessive information, wasting unnecessary resources, and guaranteeing that each process will have the necessary attention. (Livescault, n.d.).

Practically, to legitimately understand these innovation metrics, we need to look attentively at empirically validated frameworks for innovation KPIs implementation in previous literature.

c. Theoretical Frameworks Related to Innovation KPIs

Several studies with different methodologies and data assessments have recently been conducted to define categories of innovation KPIs assessed through questionnaires.

Consequently, applying one to each specific case must be an initial stage of every innovative metric implementation.

In a literature review, Nappi and Kelly (2022) identified a total of 259 performance indicators that describe both Internal and External variables (i.e., context-specific and particular to the organisation dimensions, respectively) and systematized into 9 dimensions (broadly related to environment and market, strategy, culture, and various management areas including some dimensions related to innovation such as innovation environment and innovation strategy). They divided the dimensions into 21 measurement areas to simplify the initial poll, making sure to include the essential performance indicators (Appendix 4).

Dani and Gandhi (2021) created a conceptual framework of 11 innovation indicators, with a systematised analysis of 175 from the review of articles written since 1980. In the article, they defined innovation drivers at both the Organisational level (culture, learning and knowledge management, structure and processes, strategies and investment) and Individual ones (related to sole creativity, motivation and leadership) that impact the innovation outcome (Appendix 5).

Zhen et al. (2009) proceeded to develop a framework for an innovation performance audit focused on Inputs, Processes, and Outputs, which they then validated by engaging with executive and R&D managers (Appendix 6). The authors defined 26 KPIs divided according to the phases of innovation implementation outlined above (Appendix 7). Input in innovation is conceptualized as the Innovation Availability inside the organisation by looking at the resources that are accessible to it, including financial, human, structure and knowledge capital. Innovation Efficiency describes the process component of the framework, which focuses on the procedures put in place to guarantee the success of technical innovation, evaluating quantity, quality, cost and time. The firm's achievement of its technical innovation aims is assessed in the third and final component, which effectively measures the Innovation Effect, or outputs, namely

knowledge, business and social performance. The study essentially conceptualises innovation measurement in terms of availability, efficiency, and effect, offering a more precise and comprehensive assessment of a firm's innovation performance.

By conciliating the three approaches suggested by the authors, it is possible to acknowledge the interrelationships and dependencies between them (Figure 1). While internal (which may encompass both individual and organisational indicators) and external dimensions make inputs and processes dependent, outputs are also an important source of information concerning the internal and external workings of the company. Inputs, processes and outputs are, thus, central due to their importance, wide involvement and relationship with each other.

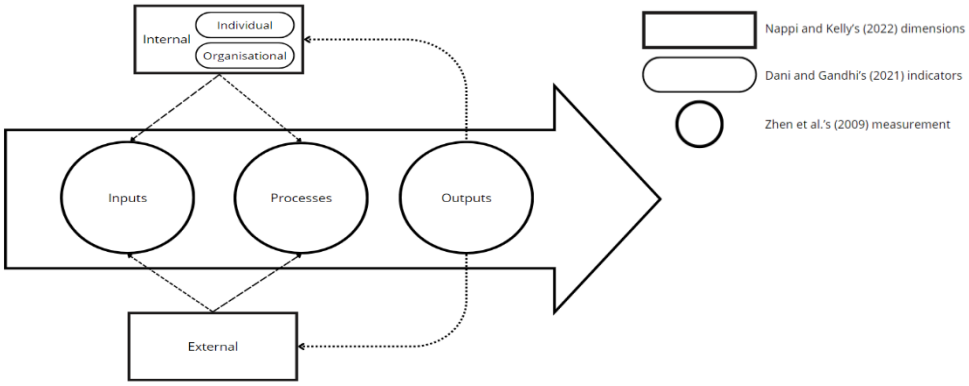

Figure 1- Combination of the theoretical frameworks for innovation KPIs

Therefore, this approach (Zhen et al.'s 2009 framework) will be adopted in the current analysis to comprehend the most urgent KPIs to implement in the company. This is also believed to be the most informative model for this study as the context in which it was applied overlaps with the objectives of the thesis and the characteristics of the PTS. In other words, the framework was verified in a highly technological environment (like PTS's acting one), at a firm level, including all the steps of innovation from the ideation to the value created (meeting the objective of this thesis).

Once the frameworks have been decided upon, there is an inevitable requirement to understand the alignment between innovation and operations and how it can be promoted by the implementation of innovation KPIs, to accomplish the objective proposed.

d. The concept of Innovation-operational Alignment

The concept of innovation-operational alignment is included in the organisational one, a critical aspect of the performance. It refers to the degree to which an organisation's innovation strategies and activities are aligned with its operational ones (Lauenroth 2023). According to Abbas (2023), the implementation of strategic/corporate innovation KPIs may contribute to this alignment, which is crucial for ensuring that the organisation's innovative efforts contribute effectively to its overall performance (Fortuin 2006).

Santa et al. (2009) scrutinised the alignment of technology innovation and operational effectiveness. They identified that people tend to focus overly on system effectiveness, or the resulting effectiveness, which may be harmful to the long-term success of the business. The authors also concluded that technology innovation effectiveness correlates significantly with elements that stimulate organisational alignment.

Another study conducted by Santa et al. (2010) discusses the significance of strategic alignment, based on a two-stage methodological approach of literature review and interviews. The findings revealed that performance improvements can be achieved by aligning technological innovation effectiveness with operational effectiveness.

Provided the importance of the alignment between innovation and operations, assessment methods beyond KPIs have been proposed. Santiago and Soares (2020) suggest the implementation of "buckets" that establish R&D resource allocation in line with the objectives of the company. This approach shares many properties with those highlighted as central for KPI effectiveness, namely dynamic and recursive implementation in dynamic contexts (Santos, 2017) - thus providing an interesting alternative that can complement the usage of innovation KPIs. All these literature assumptions should now be transposed to PTS's reality so the metrics implemented ensure control over innovation and generalized organisational alignment, considering the above-outlined – and, more importantly, empirically-validated – frameworks.

3. The Company

Portugal Technology Solutions is a well-known private organisation. Over time it has expanded to offer a broad variety of services including training, testing, inspection and technical consultation based on advanced quality solutions, having in mind social responsibility, seeking to support the clients in increasing their performance and lowering uncertainty and risks ("___ – Engenharia Portugal," n.d.).

Their vision is to be acknowledged as an independent technological organisation with a global reach that develops and offers services, and creative and integrated solutions guided by their core values of competence, and innovation.

The Group has a global existence, following an expansion strategy that allowed it to be present in countries in Europe, South America, Africa and Asia, with hundreds of international innovation projects and employees (___ Group 2016).

According to "Relatório e Contas ___ | Contas Individuais 2022," (n.d), the company is structured with a Board of Directors that is in charge of the 3 groups of Units (Appendix 8): 1) Transversal Units, 2) Operational Units: Regulatory Services (RS), Laboratories (Lab) and Engineering Services (ES) -, and 3) Autonomous Units: Training (Train), Innovation Unit (IU), Specialised Laboratories (SL) and Life Sciences Laboratories (LSL) (Appendix 9). Each of the Operational and Autonomous Units is responsible for Departments that integrate Services that are assured by teams controlled by "technical and research specialists". (Appendix 10). These managers and specialists in every Unit, Department, and Service carry out orders issued by their respective superiors in the structure, ensuring the efficiency and quality of the outputs generated by the teams they oversee.

Although PTS has, at the moment, an internal innovation program called "*Innovation Lab*" to incentivise the workers to present suggestions on innovation to be implemented, according to

Viegas (2023), PTS's innovation culture is currently facing some challenges. The thesis highlighted, among others, the inexistence of innovation KPIs in Units other than in the Innovation Unit (IU) – in fact, these departments evaluate performance through 3-to-4 financially driven KPIs alone. Even within strategic and corporative KPIs, common across PTS departments, there are only 3 main broad annual targets. All this contributes to the misalignment between IU and all the Other Units (OU), which will be countered through the implementation of innovation KPIs, in this study.

This author's suggestion, in combination with the literature, was used as the basis for the following analysis - the extension of innovation KPIs to ensure organisational alignment. It is necessary, thus, to answer the following research questions:

1. What are the respondents' perceptions of the company's current degree of innovation and how is it influenced by the nature of the Unit's functions (IU vs OU) and the length of time working in the company?
2. How are the domains of innovation availability (inputs), innovation efficiency (processes) and innovation value (outputs) perceived in the company's ongoing innovation by Units and years in the company?
3. How do Directors and Specialists assess the 26 innovation KPIs and how do their perceptions change across Units and years in the company responses?
4. Do the data support the literature's assertion that there is a mismatch between the company's operations and innovation?
5. What are the most compelling KPIs for the PTS environment according to its managers and specialists?

4. Research Method

Based on the objective of defining innovation KPIs for the company, and adopting the stages underlying said process defined by Deschamps and Lakiza's (2018), it is possible to establish the steps of the research to be carried out (Figure 2). Provided that a set of innovation KPIs – those proposed by Zhen et al. (2009) – has been selected, the stakeholder input phase should ensue in the form of a questionnaire.

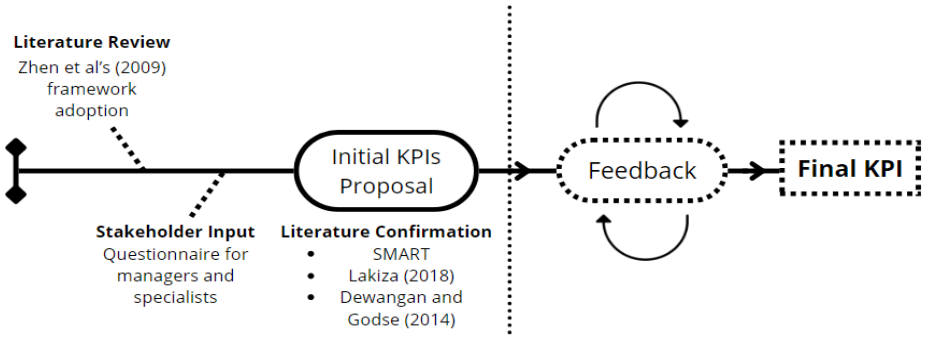

Figure 2 - Conceptual Map. Adapted from Deschamps and Lakiza's (2018)

The questionnaire was made up of close-ended questions, with an open-ended section for comments at the end. This quantitative approach enables the participation of a sizable group of staff, allowing for a meaningful interpretation of a wide scope of response patterns embedded within the company through credible data. This empirical approach can inform the creation of innovation KPIs that abide by PTS' alignment, understanding what the workers believe to be the crucial aspects to tackle in this innovation metrics implementation.

a. Data Collection

The data were collected through a survey distributed to all directors of Operational and Autonomous Units, including the directors of the correspondent Departments, Services and research and technical Specialists, defining a population of 113 people. This sample was selected as its characteristics overlap with those of the population considered in the framework that informed the present approach (i.e., developed by Zheng et al. 2009), which focused on executives and R&D managers. The intention was to include the operational and innovation

activities' managers and specialists to transpose the authors' scheme. This population is knowledgeable and performs management and decision-making functions, lying midway between fully operational (i.e., in the field) and strategic (i.e., in the office) functions – enabling the two sides of information to converge.

The Board of Directors and Transversal Units were not included in the study since their roles are essentially strategic, and not taken into consideration in the original framework confirmation (Zhen et al.'s 2009). Instead, for the present work, the goal was to highlight the implementational aspect of PTS's workflow, namely operations and innovation as conceptualized by the operational management.

The survey was sent via email by the Human Resources Department, accompanied by the warranty of its anonymity, confidentiality and voluntary nature. Before, the questionnaire was scrutinised and adjusted by this Department and by the Innovation Unit, to ensure it was in line with internal quality and corporate ethics guidelines.

The survey, provided both in Portuguese and English (Appendix 11), is composed of 3 main blocks. Employees first rated general innovation and in the three broad areas defined by Zhen et al.'s (2009) framework (i.e., Innovation Availability, Innovation Efficiency and Innovation Value). This sought to provide insights into the perception of the current innovation success and have a general idea of innovation in the steps of the productive process (from resources to results, passing through the procedures in between).

Secondly, employees evaluated each of the 26 KPIs explored using a scale from 1 to 7 (i.e., as Zhen et al's (2009) framework validation study). The objective was to understand how each employee perceives the relevance of these monitoring variables for the success of PTS's innovation strategy. To anticipate possible misinterpretation or miscomprehension from the respondents, a brief explanation of each KPI was displayed in the survey (Appendix 12).

Finally, employees answered demographic questions, namely on their role in the company and the extent to which they have been employed at PTS. These were included to understand how innovation perceptions vary according to them, enabling a tentative exploration of their role in the perceived misalignment between innovation and operations. According to Woods et al. (2018) the more years in the company, the more rigorous and critical the employees are, as well as less open to disruption. These demographic questions allow for the exploration of these previously found results.

b. Data Analysis

The data were analysed and visualised using two software: RapidMiner and Excel. The first because of its versatility and ease of use allows one to work on a simple visual workflow with few operators and connections on graphs and figures. The second one was chosen to aid data cleaning, namely by composing and operating with the data within tables.

The survey was answered by a total of 27 (a response rate of 24%) managers and specialists. This sample includes all the Units (Appendix 13): IU (8 responses, 30%), ES (7, 26%), RS (4, 15%), Train (3, 11%), Lab (2, 7%), LSL (2, 7%) SL (1, 4%), and most respondents have been working in the company for a considerable time: 70% of the respondents answered having been in the company for 11 or more years (Appendix 14).

It is important to highlight that, although some variables seem to be moderately-to-strongly correlated (e.g., KPIs 24-26 or KPIs 7-8), no pair is too correlated, since none were dropped following the implementation of RapidMiner's threshold for correlated removal (i.e., of .95) (Appendix 15). Thus, no removal of superfluous attributes was unnecessary.

The analysis was split into five sections corresponding to the five research questions (pg. 11):

1. *What are the respondents' perceptions of the company's current degree of innovation and how is it influenced by the nature of the Unit's functions (IU vs OU) and the length of time working in the company?*

According to the respondents, the current degree of innovation seems lower than expected (Appendix 16) as the mode (total of 12 answers, 44%) was to pick the option "Moderately successful", followed by 8 people who considered it "Slightly successful" and only 4 respondents categorised it as "Very" or "Extremely" successful.

When confronting the IU with the OU (Appendix 17), the former group is more negative about the company's current innovation level with no responses above "Moderately successful" and a sizeable portion (25%) classifying it as "Not successful at all".

In the same way, when analysing the innovation perception by working years in the company (Appendix 18), the understanding of innovation is negative – and may increase with permanence in the company. Only 9% and 12.5% of older and most recent people gave positive evaluations, and permanently above 20 years gave more extreme negative responses (18% described it as "Not successful at all").

In other words, the innovation level is perceived as "Moderately successful" or "Slightly successful", with the IU apparently the most stringent (because of being more critical or simply more informed). In parallel, the personnel with more years in the organisation judged it the lowest, suggesting that, according to Woods et al. (2018), this can be a consequence of more criticism, rigour or information.

2. *How are the domains of innovation availability (inputs), innovation efficiency (processes) and innovation value (outputs) perceived in the company's ongoing innovation by Units and years in the company?*

Overall (Appendix 19), respondents perceive the output as the most important with a score of 5.41, followed by the input (5.30) and processes (4.96).

The IU and the OU evaluate these dimensions similarly (Appendix 20). Variability within IU's scores is, however, higher than that of OU – which is mainly due to considerably higher input and output evaluation from the first group, reflected in the 475% difference in the standard deviation values (0.52 in the first group and 0.11 in the second one). In the perusal of ratings by time in the company (Appendix 21), the only exception is the "<5" years that defended that the Inputs (5.50) are tremendously more important than Processes (3.50) and Outputs (3.00). This result should be considered with caution, as this group was underrepresented in our sample (i.e., only 2 respondents belonged to it). The same applies to respondents with higher seniority (n = 2) whose valorisation of the three variables was 6.00 points.

The output is understood as the most important to be monitored in the productive process, which is also verifiable across Units and years in the company (except for the intervals noted above and respective caveats about their sample).

3. *How do Directors and Specialists assess the 26 innovation KPIs and how do their perceptions change across Units and years in the company responses?*

Focusing the attention on the 26 innovation KPIs (Table 1), it is visible that more than 74% of them were valued at 5 points or higher (Appendix 22). The highest ranked ones were: 1) KPI 18 (i.e., the position of the firm's technology and innovation compared with competitors; mean = 6.41), 2) KPI 15 (i.e., the ratio of new technology applied in new products; mean = 5.96), and 3) KPI 14 (i.e., average total time-to-market, from concept through to launch;

Table 1 - KPIs evaluation from the questionnaire

KPI	Average	KPI	Average
1	5.00	**14**	5.85
2	5.48	**15**	5.96
3	4.33	**16**	5.52
4	5.00	**17**	4.81
5	5.44	**18**	6.41
6	5.74	**19**	5.63
7	4.70	**20**	5.74
8	4.56	**21**	5.81
9	5.07	**22**	5.00
10	5.67	**23**	5.07
11	4.30	**24**	5.37
12	4.81	**25**	5.56
13	5.22	**26**	5.56

mean = 5.85). Conversely, KPIs 3 (i.e., R&D staff, or percentage of researchers to overall employees; mean = 4.33) and 11 (i.e., average cost of R&D projects; mean = 4.30) were rated the lowest. As the standard deviation was 0.52 for an average KPI evaluation of 5.90, on a scale from 1 to 7, most of the data may not centre around the scale mid-point, indicating some variability and high-importance valuations.

When comparing the IU and the OU (Appendix 23), lower importance ascribed to KPIs was mostly driven by IU, with group differences reaching -104% (mean $_{OU}$ = 5.79 vs. mean $_{IU}$ = 4.75; KPI 2) and -135% (KPI 9), for example. IU only overscored the OU ratings for KPIs 5 (i.e., current knowledge owned), 12 (i.e., R&D/technology acquisition cost per new product or redesign) and 24 (i.e., reduced unit labour costs), and to less expressive degrees (by 8%, 26% and 1%, respectively). The dispersion of the IU's responses was again higher than that of the OU' (for a standard deviation of 0.63, 21% higher than 0.52).

The respondents working in the company for less than 5 years scored the lowest average rating across the 26 KPIs (mean = 4.80; see Appendix 24), though their responses had high dispersion (with a standard deviation of 1.41). The group of employees who had worked for the firm for 16-20 years provided the highest evaluation ratings across KPIs (mean = 5.76). Employees who had been with the organisation for 6-10 years and >20 years scored similarly, with values of around 5.20.

All the KPIs were generally highly evaluated apart from the indicators related to the percentage of researchers in the total number of employees or the average cost of R&D projects. The IU seems to be more critical compared to Other Units, as evidenced by their lower KPI ratings, especially for those that are seen as less important. Regarding the time in the company, it does not have an impact on the perception of the innovation KPIs (a value of around 5.2 was achieved by both the 6-10 years and >20 years).

4. *Do the data support the literature's assertion that there is a mismatch between the company's operations and innovation?*

To verify if the tendency of the company's misalignment highlighted by Viegas (2023) is supported – if there are considerable mean differences between the IU and OU, a two-tailed (as the hypothesis was about the existence vs. absence of a difference), independent samples t-test assuming unequal variances was conducted (with a significance level of 0.05; Appendix 25). Based on the test's values (t = 2.23, p = .18) we cannot reject the null hypothesis (about the equality of the scores across these Units). This does not, however, clearly refute previous evidence of misalignment as this result may be conditioned by the low number of respondents. Thus, the descriptive differences may be more informative than statistical tests. When looking at the former IU's perceptions of innovation KPIs are considerably more negative than those of the OU (5.03 versus 5.40). Additionally, there are some substantial differences between the IU and the OU at the individual KPI level (Appendix 26) – such as for KPIs 2 (technical improvement expenditure; -103.9%), and 10 (on-time delivery of specification to manufacturing; -134.9%), or – in the opposite direction – in KPIs 12 (R&D/technology acquisition cost per new product or redesign; 26.3%), and 22 (Market share gained due to R&D; 71.1%). Interestingly, using the same t-test analysis for each KPI, a significant difference emerges for KPI 2 (Technical improvement expenditure), with p = .024.

The above-discussed argues for support of Viegas' (2023) finding that there may be a misalignment in the company's innovation culture, with meaningful descriptive differences at the KPI level. However, this study should be extended to a wider range of respondents to prove if these descriptive tendencies become statistically significant in more powered samples.

5. *What are the most compelling KPIs for the PTS environment according to its managers and specialists?*

The KPI perceived as most important by the sample is KPI 18 (Position of the firm's technology and innovation compared to competitors). This KPI appears as the one that, by its position-comparing nature and focus, should be a priority for the company, based on the respondents. According to Hagedoorn and Cloodt (2003) using multiple indicators that can capture different dimensions of innovative performance allows us to have a more comprehensive view of the performance. However, these metrics must not be strongly correlated as, if they were so, some would be superfluous, and their importance would be overrepresented. So, to decrease the likelihood of strong correlations between to-be-implemented KPIs and factors in various dimensions, it may be beneficial to include Input, Process and Output metrics in the analysis. Considering that the highest-scoring KPI – KPI 18 – is related to outputs, the highest-scoring KPIs for inputs and processes should be considered. These are KPIs 2 (Technical improvement expenditure) and 14 (Average total time-to-market), respectively. As these only hold weak-to-moderate correlations with one another (Appendix 27), we can assume that the implementation of the three of them may support a more thorough understanding of innovation, if in line with the literature reviewed.

This suggestion of monitoring innovation appears beneficial because of the scope of the types of innovation. According to Varadarajan (2018) and Demircioglu, Audretsch and Slaper (2019), it allows for the broad inclusion of all three types of innovation, from focusing on existing products and adjustments made to production stages to shifts in internal procedures (Table 2),

which may reflect in possible innovation rearrangements in the company that may be taken into account beforehand.

Table 2 – Top-rated KPIs from survey responses on inputs, processes and outputs

Innovation KPIs	Type of Innovation	Framework Area	Score
2. Technical improvement expenditure	Product Innovation	Input	5.48
14. Average total time-to-market	Process Innovation	Process	5.85
18. The position of firm's technology and innovation compared to competitors	Organisational Innovation	Output	6.41

5. Discussion

Having proposed KPIs that are important to implement, it is now important to understand their applicability and monitoring.

- Technical Improvement Expenditure - Calculates the company's spending on new technology-related gear and equipment, trackable based on the financial reports. This data may be updated often, enabling homologous comparisons to reveal if the business is investing more or less in technology advancements. This may enable expense allocation and, ultimately, contribute to evaluating patterns in technology investment.
- Average Total Time-to-Market – Tracks each project chronology from its conceptualisation until product launch to measure the effectiveness of the innovation processes with project management tools, such that shorter time-to-market metrics represent more efficient processes. This may require intradepartmental cooperation but allows for benchmarking by comparing the company's implementation time with that of competitors.
- Technological and Innovative Position of the Firm - Assesses the comparison of inventive and technological advancements with competitors. This is trackable by regularly researching the market for rivals' developments and technical breakthroughs. This may

benefit from the aggregation of specialised focuses to assess the company's inventive standing quantitatively (e.g. patent applications or disruptive inventions).

Because of the not-so-volatile nature of each of these monitorisations, the proposal is that these KPIs should have a corporate scope and be evaluated annually, like the three existing financial ones, also as a way of simplifying processes and not wasting resources. The inclusion of all three would make it possible to cover the various areas of the production process.

These KPIs may be successfully implemented, considering that each one is SMART - namely, concrete, viably measured, achievable, pragmatic, and with a defined timeframe of appliance and monitorisation (for a detailed scrutiny, check Appendix 28). Nevertheless, their implementation should be carefully considered, to adapt it to the company's reality, particularly in terms of framing the KPIs into the company's reality (numerically).

They are in line with the essential properties suggested by Lakiza (2018). The three together, theoretically, encourage self-initiative by allocating funds for the improvement of innovative procedures or systems, concentrating on intangibles and deviating the focus from the results to common objectives. The advancements expenditure enables the company to track employee learning and the average time-to-market focus on projecting future processes, in a dynamic, informal and unstructured system (thorough examination in Appendix 29).

Leaning towards the principles research conducted by Dewangan and Godse (2014), monitoring innovation through these three KPIs comes across as a multi-faceted, easy-to-use system that assesses the performance of each step within the innovation cycle including the whole productive process (from inputs to outputs), addresses the aims of organisational stakeholders, and enhance comprehension of the causal links within these processes (Appendix 30, in-depth analysis).

Nevertheless, it is important to keep in mind that this study is not without its limitations. The most obvious is the difficulty in obtaining a meaningful number of answers and assuring their credibility. Particularly, the fact that the survey is labelled as being conducted by a Master's student – that most collaborators do not know and/or may feel uncomfortable sharing ideas with – may have hindered both response rate and response quality. Note that statistical tests employed require a sample size of around 30 respondents to assure the robustness of the corresponding conclusions. With a final sample comprised of 27 responses, this robustness may be objectionable, and strong claims should be approached with caution.

Additionally, the representation of the different units does not replicate their distribution in the company. Some are underrepresented – namely Labs, LSL, and SL with 2, 2 and 1 responses, respectively –, while others are overrepresented – such as IU and ES with 8 and 7 respondents. As such, some clusters of feedback (and assuming that individuals within a unit tend to be more similar than across units) may be overrepresented compared with others, which makes it more difficult to make fair comparisons across the espoused views on innovation.

Moreover, the study relied on a brief survey (i.e., condensed into a short around-6-minute version) to reduce a low response rate. This can limit the diagnosis as more information would contribute to reinforcing it and even identifying different perspectives.

This way, although this attempt is encouraging in terms of moving forward with the innovation KPI agenda, there is still work to be done, particularly in terms of overcoming the limitations expressed above.

6. Conclusions and Final Reflection

This analysis was constructed on the importance of innovation and its monitoring. Taking into account the Portugal Technology Solutions reality, and previous studies on the company, there is a lack of innovation metrics apart from those implemented at the IU and, consequently, a plausible misalignment between the innovative activities and the operational ones. According to Abbas (2023), the implementation of strategic/corporate innovation KPIs may contribute to this alignment as it will contribute to common efforts and objectives.

This process starts with a literature review and stakeholder input (Deschamps and Lakiza 2018). In this case, adopting the innovation KPIs framework suggested by Zhen et. al (2009), and after having the Operational and Autonomous Units' managers and specialists' feedback, KPIs 2 (Technical improvement expenditure), 14 (Average total time-to-market), and 18 (The position of the firm's technology and innovation compared to competitors) were pointed out as more urgent to be tackled. Being these SMART, viable according to the principles and characteristics analysed, and not highly correlated, they seem to be applicable. To increase the likelihood of their successful implementation, they should be considered in the context of existing evaluation metrics and replicate their essential characteristics, such as assessment regularity (i.e., annual).

Creating a feedback loop to promote continuous development, by allowing the KPI monitoring data to be incorporated back into the innovation, will be crucial to this monitoring. Later on, some others may emerge as plausible follow-up innovation dimensions for the company to consider.

Similarly, for companies who are praised for being highly technological and disruptive, this scrutinising approach for the applicability of innovation KPIs and their alignment turns out to be essential to further foster innovation and ensure it overlaps with strategic goals, increasing the prospects of the organisation. The KPIs framework adopted and the sample for stakeholder input may vary, but the rationale shall be transposed.

Eventually, further studies should verify and complement the study for the PTS-specific case:

- Innovation KPIs framing and validation: The metrics suggested should be validated by interviewing, specifically, the Board of Directors, since they should be applied throughout the corporation. This will not only help ensure that they are reliable and applicable but also frame the KPIs into the company's reality to make them practical and numerical (e.g., defining the exact amount the company should spend on acquiring new technology-related machinery and equipment; defining the timeline, on average, to market a new product/service from the ideation).
- Innovation KPIs implementation: Trace a protocol for implementing the innovation metrics identified to ensure their integration into the company's culture and context. This analysis may be combined with: (a) a communication plan (to ensure that employees and stakeholders understand the KPIs' importance and applicability); and (b) a training program (to guarantee that employees have the necessary skills and knowledge to implement the KPIs, especially in roles responsible for their application and control).
- Innovation KPIs monitoring: Develop a system for monitoring and reporting on the innovation metrics identified. Supervising roles and structure should help ensure the metrics are being used effectively to progress towards its innovation goals.
- Organisational alignment: Analyse the calibration between innovation and operations separately, to understand and fight back the possible misalignment, strengthening the KPIs' effectiveness. The strategic buckets (Santiago and Soares 2020) method can be used as the basis for this analysis to compare the innovation KPIs suggestion with the conclusion of the categorisation of projects into different buckets (technology, market, capabilities, organizational processes and external environment) based on their strategic importance and the characteristics to allocate resources and align R&D portfolio with the business strategy.

In the same way, further literature steps can also be traced to enrich the theme and empower future investigators:

- Standardised framework creation: Create a systematised framework for innovation KPI implementation, supervision, and assessment, taking into account variables such as organisation size or industry, leading to a more standardized approach to the application of innovation KPIs across companies.
- Comparative case studies: Conduct comparative innovation KPIs case studies in diverse sectors to perceive different strategies and procedures, highlighting the success factors, difficulties encountered, and effects of these measures on the performance of the organisation. This would make it possible to better plan this implementation in various circumstances, as well as to define possible limitations of the transposition of the approach used in this case.
- Employee engagement and innovation KPIs: Examine the connection between staff engagement and motivation and the implementation and efficacy of innovation KPIs. It could involve trying to transpose the conclusion that the correct implementation of KPIs can lead to employee motivation and consequent improvement in results (Marr 2021), to the reality of innovation ones.

In conclusion, considering Portugal Technology Solutions' context, the opportunity to settle on annually monitored miscellaneous corporative Innovation KPIs should be taken into consideration as it may be a vital step to achieve organisational alignment. More research following the current one, as well as extensive validation, implementation, and monitoring, will be required by PTS to achieve seamless integration of innovation into the company's key operating areas and long-term innovation and overall success.

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8. Appendix

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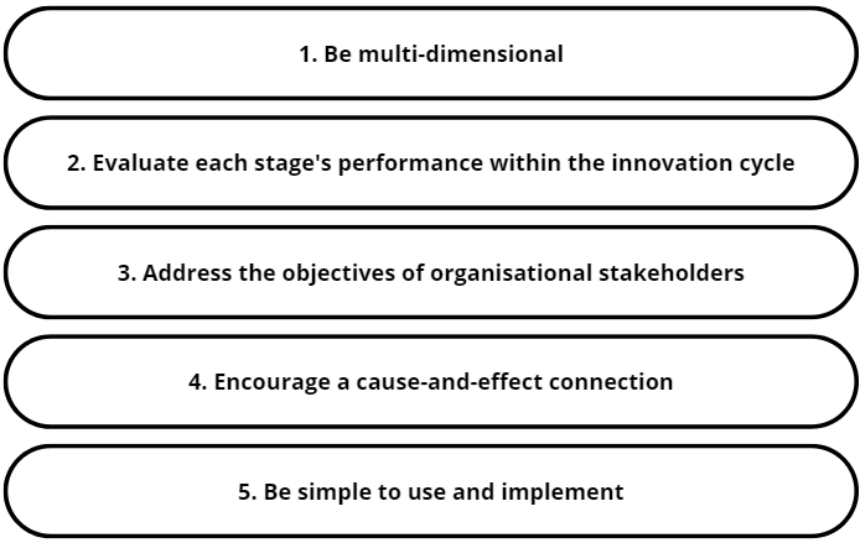
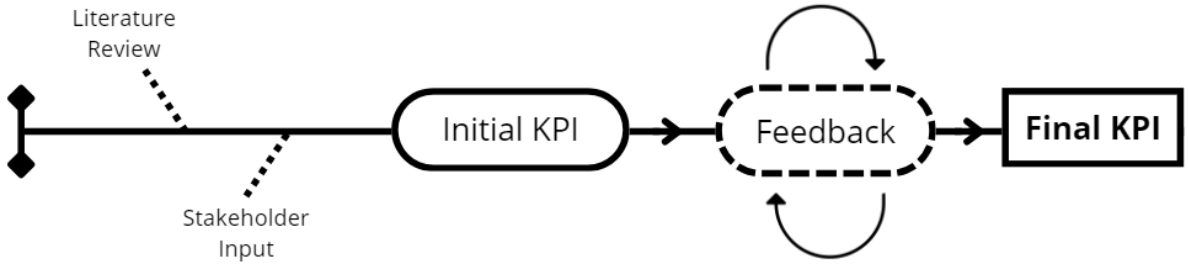
Appendix 1 - Performance measurement systems characteristics. Adapted from Lakiza (2018)

Characteristics	Description
Encouragement of initiative taking	Motivate staff members to be proactive and take the initiative at work.
Focus on intangible aspects	Pay attention to the intangible elements of a company, such innovation, staff morale, and customer happiness.
Focus on objectives as opposed to results	Focus on objectives as opposed to results, as objectives will provide a motivating purpose and direction based on a shared ambition.
Measurement of employee learning and continuous development	Evaluates the growth and learning of employees throughout time.
Focus on forecasting future processes as opposed to controlling past activities	Predict future procedures and results as opposed to managing previous actions.
Dynamic and flexible	Adaptable and modifiable to accommodate evolving organisational requirements.
Informal and loose	Informal and loosely organised, fostering more inventiveness and adaptability.
Focus and strategy and vision as opposed to finance and controls	Prioritise strategic objectives and vision over financial controls.

Appendix 2 - Guiding principles for successful performance measurement. Adapted from Dewangan and Godse (2014)



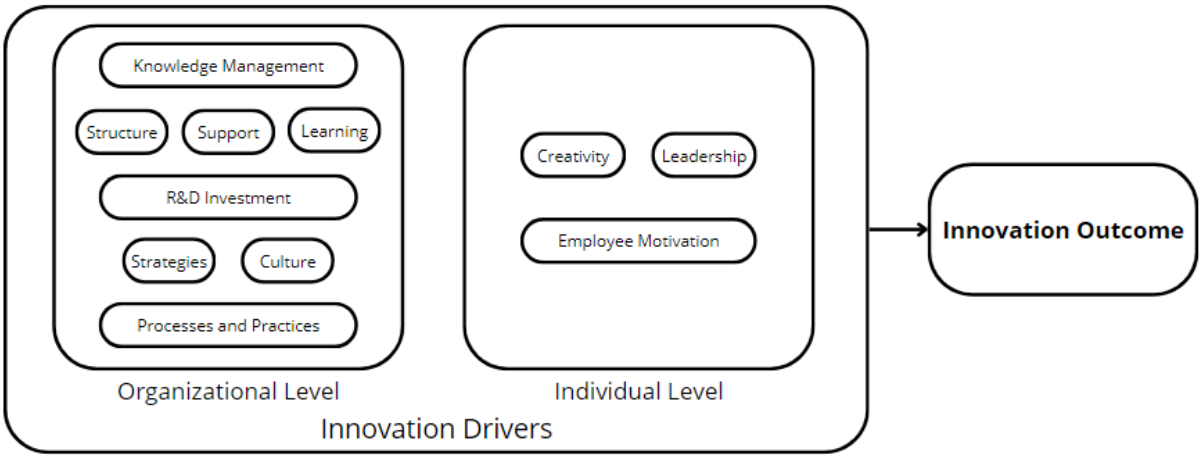
Appendix 3 - Innovation KPI development flow. Adapted from Deschamps and Lakiza (2018)



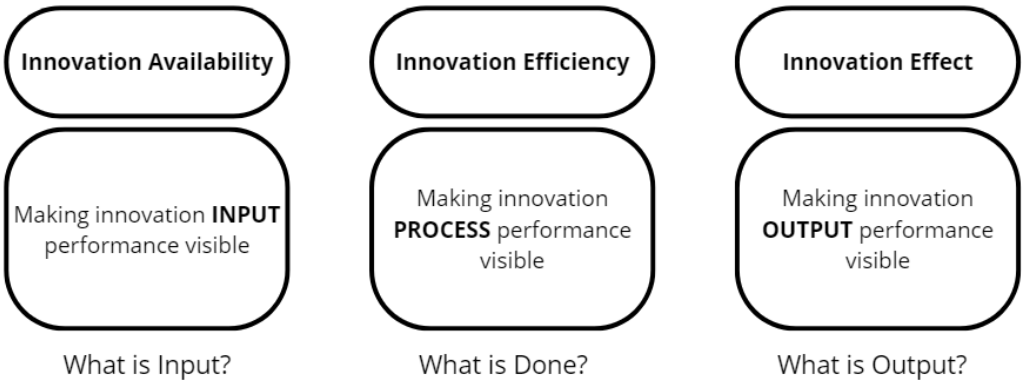
Appendix 4 - Performance dimensions and indicators. Adapted from Kelly and Nappi (2022)

Dimensions		Performance Indicators
External	Technology Management	Technology Orientation
		Techonolgy Potential
		R&D
	Market	Market Research and Testing
		Market Monitoring
	Innovation Environment	Openness
		Servitisation
		Sustainability
Internal	Project Management	Project Efficiency
		Tools
	Team Management	Cross-functionality
		Team Stability
	Knowledge Management	Idea Management
		Knowledge Repository
		Information Flows
	Portfolio Management	Balance
		Evaluation Tools
	Organisation and Culture	Culture
		Structure
	Innovation Strategy	Innovation Orientation
		Leadership

Appendix 5 - Innovation drivers. Adapted from Dani and Gandhi (2021)



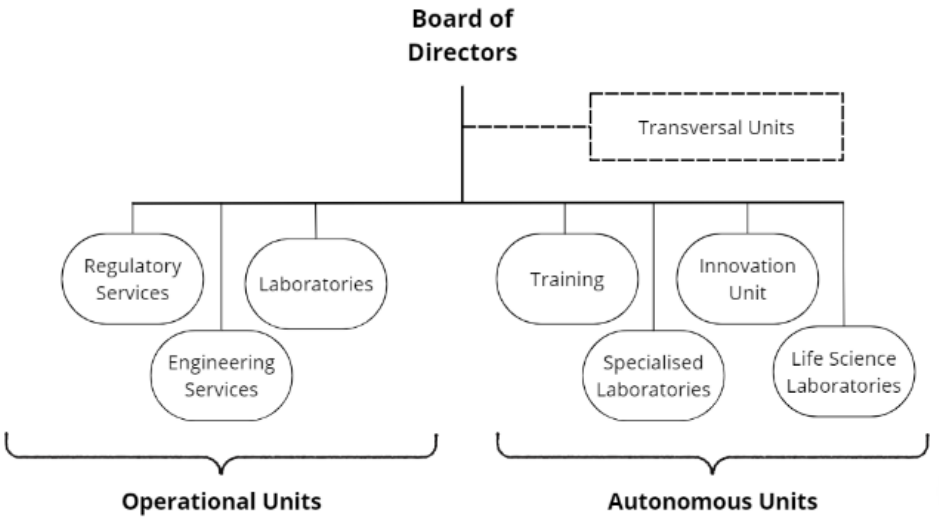
Appendix 6 - Innovation Measurement. Adapted from Zhen et. al (2009)



Appendix 7 - Innovation KPIs. Adapted from Zhen et. al (2009)

No	Innovation Measurement	Innovation KPI
1	Availability	R&D Expenditure (R&D intensity)
2		Technical Improvement Expenditure (Acquisition of new machinery and equipment related to innovations)
3		R&D Staff (Percentage of researchers to overall employees)
4		External support (Collaboration with other firms or R&D centres)
5		Current Knowledge Owned (Patent intensity)
6	Efficiency	Number of New Products/Services or Redesigns
7		Number of Patents
8		Number of Licenses
9		Success Rate of R&D Projects
10		On-time Delivery of Specifications to Manufacturing
11		Average Cost of R&D Projects
12		R&D/Technology Acquisition Cost per New Product/Service or Redesign
13		Average Development Time of R&D Projects
14		Average Total Time-to-market (from concept through to launch)
15	Value	The Ratio of New Technology Applied in New Products
16		The Ratio of New Technology Applied in New Production Process
17		The Potential Value of Patents and Licenses
18		The Position of Firm's Technology and Innovation Comparing with Competitor
19		New Sales Ratio (Percentage sales by new products)
20		Cost Saving Ratio (Percentage cost saving by new technology)
21		Percentage Profit due to R&D
22		Market Share Gained due to R&D
23		R&D Productivity (Expected or realized IRR/ROI of R&D expenditures)
24		Reduced Unit Labour Costs
25		Reduced Consumption of Materials and Energy
26		Reduced Environmental Impacts

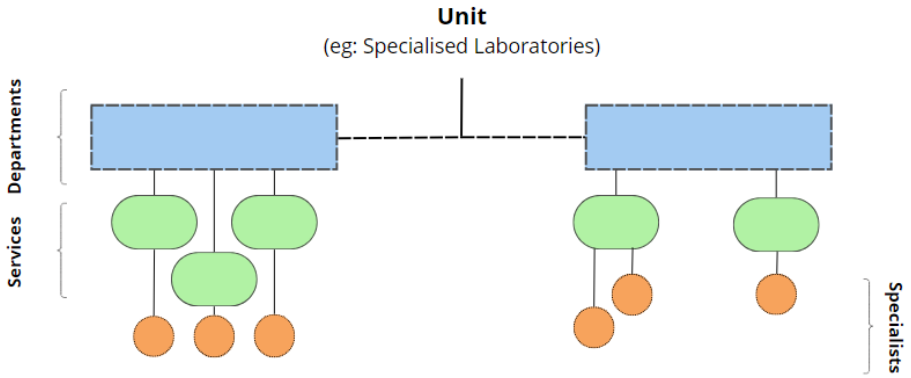
Appendix 8 - Company Organogram. Adapted from the company organogram



Appendix 9 - Company units and description. Adapted from the company organogram

Unit		Acronym	Description
Operational Units	**Regulatory Services**	**RS**	Primarily focused on delivering regulatory services, including gas, electrical, lift, and work equipment inspections. It also offers services related to safety and the environment.
	Laboratories	**Lab**	Works with testing, calibrations, and laboratory consulting. It functions in every industry area, with an emphasis on the automotive, pharmaceuticals, oil and gas, and health and hospitality assisting its clients in making decisions and ensuring procedures, goods, and services.
	Engineering Services	**ES**	Dedicated to carrying out engineering and asset condition assessment of industrial assets, integrating various dimensions (project analysis, consultancy and engineering, technical inspections, tests and audits).
Autonomous Units	**Training**	**Train**	Emphasis on innovation, digital transformation, and sustainability, promotes the upskilling and reskilling by encouraging employee certification and validation.
	Innovation Unit	**IU**	Focus on developing new products/services, with greater incorporation of technology and knowledge, which reinforce the offer, value and competitiveness in the market.
	Specialised Laboratories	**SL**	Dedicated to carrying out thermodynamics tests and verification tests on technological demonstrators, for aerospace, automotive and energy.
	Life Sciences Laboratories	**LSL**	Combines areas of activity related to agriculture, environment and the food and pharmaceutical industry.

Appendix 10 - Company units' structure. Adapted from the company organogram



Appendix 11 - Survey conducted (english and portuguese)

Start of Block: 1

In which language would you prefer to answer this survey? (ENG)
Em que língua prefere responder a este questionário? (PT)

- ○ English (ENG)
- ○ Português (PT)

End of Block: 1

Start of Block: E1

Dear Participant,

The present survey is being conducted as part of a Master's Thesis on "INNOVATION KPIs TO FOSTER INNOVATION AND OPERATIONS ALIGNMENT" at Portugal Technology Solutions - PTS. Innovation KPIs align team activities with innovation objectives, providing a clear path and shared understanding of innovation. They facilitate progress tracking, ensuring everyone works towards the same goals, thereby enhancing efficiency and fostering an innovative culture.

We assure you that your responses will be kept confidential and anonymous, and you are free to stop answering at any moment if you wish to do so.

The survey should take approximately 6 minutes to complete. We appreciate your time and effort in helping us with this study.

If you have any further questions or need additional information, please feel free to reach out to Bernardo Cruz (56120@novasbe.pt). Your feedback and inquiries are always welcome.

Thank you in advance for your participation!

- ○ I consent to participate in the survey.
- ○ I do not consent to participate in the survey.

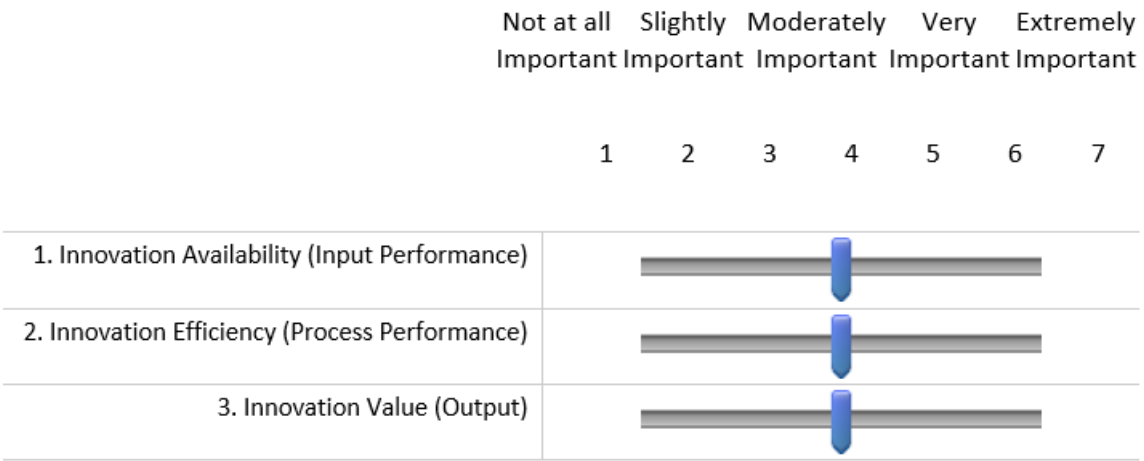
End of Block: E1

Start of Block: E2

In your opinion, how successful is the company's current level of innovation?

	Not Successful at All	Slightly Successful	Moderately Successful	Very Successful	Extremely Successful
Current Innovation Level	○	○	○	○	○

In your view, on a scale of 1 (Not at all Important) - 7 (Extremely Important), how important are the following areas when it comes to the company's continued innovation?
(If not sure what any of the categories mean, see the short individual descriptions in the text box below the question).



1. Innovation Availability - Resources a company invests in innovation.
2. Innovation Efficiency - How well a company transforms these resources into innovative outputs.
3. Innovation Value - The value generated by the company's innovative activities.

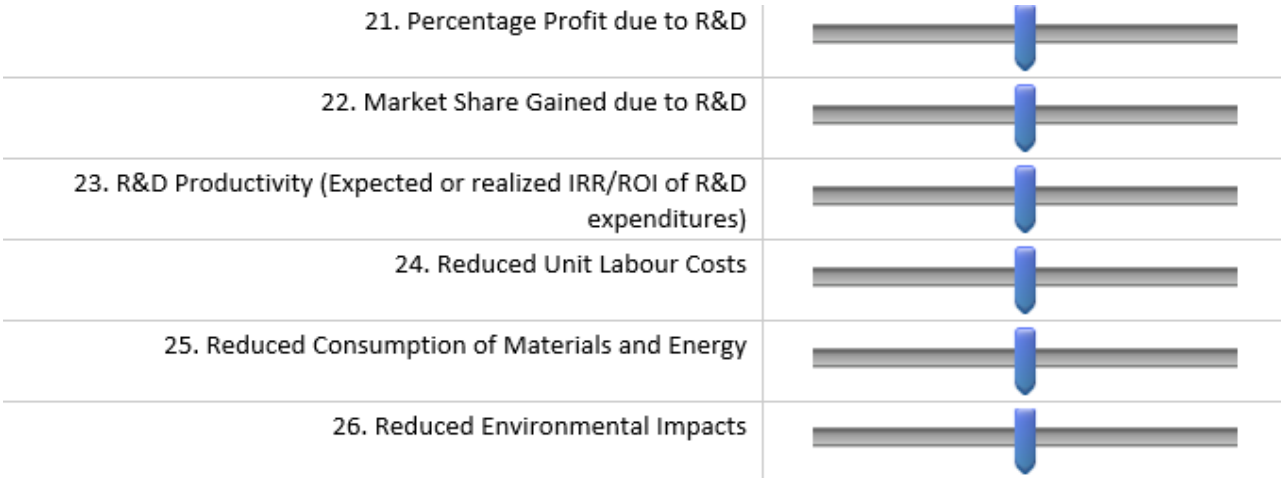
End of Block: E2

Start of Block: E3

In your view, on a scale of 1 (*Not at all Important*) - 7 (*Extremely Important*), how important are the following categories when it comes to the company's continued innovation?

(If not sure what any of the categories mean, see the short individual descriptions in the text box below the question).


Not at all Important
Slightly Important
Moderately Important
Very Important
Extremely Important
1
2
3
4
5
6
7
1. R&D Expenditure (R&D intensity)
2. Technical Improvement Expenditure (Acquisition of new machinery and equipment related to innovations)
3. R&D Staff (Percentage of researchers to overall employees)
4. External support (Collaboration with other firms or R&D centres)
5. Current Knowledge Owned (Patent intensity)
6. Number of New Products/Services or Redesigns
7. Number of Patents
8. Number of Licenses
9. Success Rate of R&D Projects
10. On-time Delivery of Specifications to Manufacturing
11. Average Cost of R&D Projects
12. R&D/Technology Acquisition Cost per New Product/Service or Redesign
13. Average Development Time of R&D Projects
14. Average Total Time-to-market (from concept through to launch)
15. The Ratio of New Technology Applied in New Products
16. The Ratio of New Technology Applied in New Production Process
17. The Potential Value of Patents and Licenses
18. The Position of the Firm's Technology and Innovation Compared with Competitor
19. New Sales Ratio (Percentage sales by new products)
20. Cost Saving Ratio (Percentage cost saving by new technology)



1. A company's R&D expenditure to its revenue ratio.
2. Making purchases of new equipment relating to innovation.
3. The proportion of workers participating in the company's research and development activities.
4. The degree to which the company collaborates with other innovative parties that might foster mutualism (such as other companies or research and development institutes).
5. The capacity to create new technologies and concepts based on information gained and technical advancements.

6. The quantity of brand-new goods, services, or redesigns the business has created.
7. The quantity of patented goods and services that the company has.
8. The quantity of licenced goods and services the company possesses.
9. The proportion of research and development initiatives that meet their goals and are deemed successful.
10. The percentage of times the manufacturing team receives the specifications for a new good or service on time.

11. The average financial outlay for every research and development project
12. The expenditure of R&D or purchasing new technology for each new product, service, or redesign.
13. Average time spent on the creation of R&D projects.
14. The mean duration of the ideation to market launch process.
15. The proportion of goods and services that use recently adopted technology.

16. The proportion of innovative technology used in production processes.
17. The projected value of the business's licences and patents.
18. The inventive and technological standing of the company in comparison to its rivals.
19. The portion of new product sales that the firm generates overall.
20. The percentage of expenses saved as a result of new technology.

21. The portion of earnings attributable to innovation-related activity.
22. The share of the market share growth that may be attributed to innovative initiatives.
23. Research and development productivity (measured in terms of ROI - Return on Investment; or IRR - Internal Rate of Return).
24. Innovation leads to a decrease in labour expenses per unit.
25. A decrease in material and energy usage due to disturbance.
26. Lessening of innovative solutions' negative environmental effects.

End of Block: E3

Start of Block: E4

In which Unit of the company do you work?

- ○ Regulatory Services (RS)
- ○ Laboratories (Lab)
- ○ Engineering Services (ES)
- ○ Training (Train)
- ○ Innovation Unit (IU)
- ○ Specialised Laboratories (SL)
- ○ Life Sciences Laboratories (LSL)

How many years have you been working at PTS?

- ○ 5 years or less
- ○ 6 years - 10 years
- ○ 11 years - 15 years
- ○ 16 years - 20 years
- ○ More than 20 years

End of Block: E4

Start of Block: E5

Do you have any suggestions or corrections to improve our study? Please write them down below or contact us by email (56120@novasbe.pt).

Your feedback is valuable to us and will help us improve future studies.

_____

End of Block: E5

Start of Block: P1

Caro Participante,

O presente questionário está a ser realizado no âmbito de uma Tese de Mestrado sobre "KPIs de INOVAÇÃO PARA PROMOVER O ALINHAMENTO DA INOVAÇÃO E ÁREAS OPERACIONAIS" no STP – Soluções Tecnológicas de Portugal.
Os KPIs de inovação alinham as atividades com os objetivos de inovação, proporcionando um caminho claro e uma compreensão partilhada da inovação. Facilitam o acompanhamento do progresso, assegurando que todos trabalham para os mesmos objetivos, aumentando assim a eficiência e promovendo uma cultura inovadora.

Asseguramos-lhe que as suas respostas serão mantidas confidenciais e anónimas, sendo livre de deixar de responder em qualquer momento que o deseje.
O questionário deverá demorar cerca de 6 minutos a ser preenchido. Agradecemos o seu tempo e esforço para nos ajudar com este estudo.

Se tiver mais alguma dúvida ou precisar de informações adicionais, não hesite em contactar - Bernardo Cruz (56120@novasbe.pt). Os seus comentários e sugestões são sempre bem-vindos.

Agradecemos desde já a sua participação!

- ○ Consinto a participação no questionário.
- ○ Não consinto a participação no questionário.

End of Block: P1

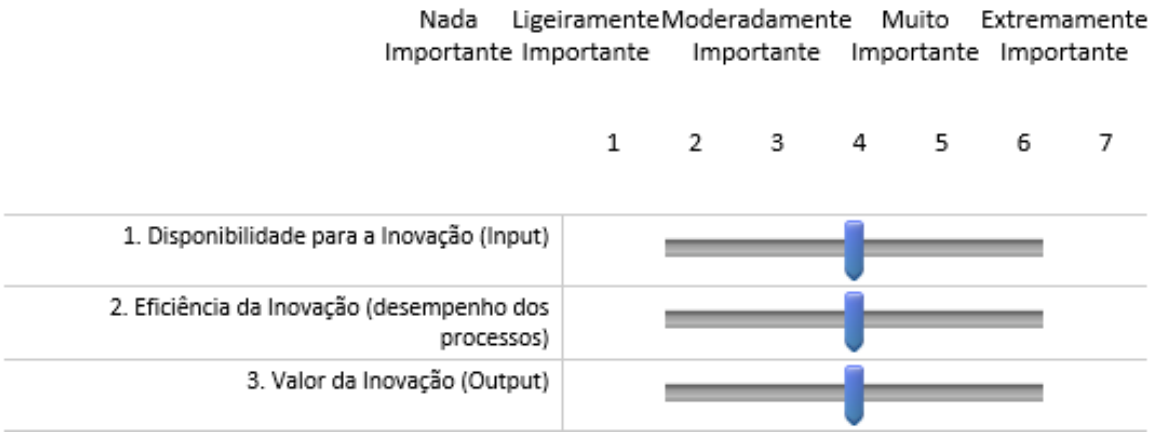
Start of Block: P2

Na sua opinião, qual é o grau de sucesso do atual nível de inovação da empresa?

	Nada Bem-Sucedido	Ligeiramente Bem-Sucedido	Moderadamente Bem-Sucedido	Muito Bem-Sucedido	Extremamente Bem-Sucedido
Nível de Inovação	○	○	○	○	○

Na sua opinião, numa escala de 1 (Nada Importante) a 7 (Extremamente Importante), qual a importância dos seguintes domínios para a inovação contínua da empresa?

(Se não tiver a certeza do significado de alguma das categorias, consulte as breves descrições individuais na caixa de texto por baixo da pergunta).



1. Disponibilidade para a Inovação - Recursos que a empresa investe em inovação.

2. Eficiência da Inovação - Forma como a empresa transforma esses recursos de forma inovadora.

3. Valor da Inovação - Valor gerado pelas atividades inovadoras da empresa.

End of Block: P2

Start of Block: P3

Na sua opinião, numa escala de 1 (*Nada Importante*) a 7 (*Extremamente Importante*), qual a importância das seguintes categorias no que respeita à inovação contínua da empresa?

(Se não tiver a certeza do significado de alguma das categorias, consulte as breves descrições individuais na caixa de texto por baixo da pergunta).


Nada Importante
Ligeiramente Importante
Moderadamente Importante
Muito Importante
Extremamente Importante
1
2
3
4
5
6
7
1. Despesas de I&D (intensidade de I&D)
2. Despesas de Melhoria Técnica (aquisição de novas máquinas e equipamentos relacionados com inovação)
3. Pessoal de I&D (Percentagem de trabalhadores em I&D em relação ao total de trabalhadores)
4. Apoio Externo (Colaboração com outras empresas ou centros de I&D)
5. Conhecimentos atuais (intensidade de patentes)
6. Número de Novos Produtos/Serviços ou Redesigns
7. Número de Patentes
8. Número de Licenças
9. Taxa de Sucesso dos Projetos de I&D
10. Entrega Atempada das Especificações ao Fabrico
11. Custo Médio dos Projetos de I&D
12. Custo de Aquisição de I&D/Tecnologia por Novo Produto/Serviço ou Remodelação
13. Tempo Médio de Desenvolvimento de Projetos de I&D
14. Tempo Médio Total de Colocação no Mercado (desde a conceção até ao lançamento)
15. Rácio de Novas Tecnologias Aplicadas em Novos Produtos
16. Rácio de Novas Tecnologias Aplicadas em Novos Processos de Produção
17. O Valor Potencial das Patentes e Licenças
18. A Posição da Tecnologia da Empresa em Relação à dos Concorrentes
19. Rácio de Novas Vendas (percentagem de vendas de novos produtos)
20. Rácio de Poupança de Custos (Percentagem de poupança de custos por nova tecnologia)

21. Percentagem de Lucro devido a I&D	
22. Quota de Mercado obtida graças à I&D	
23. Produtividade da I&D (TIR/ROI prevista ou realizada das despesas de I&D)	
24. Redução dos Custos Unitários de Mão de Obra	
25. Redução do Consumo de Materiais e Energia	
26. Redução dos Impactos Ambientais	

1. O rácio entre as despesas de I&D e as suas receitas.
2. Aquisição de novos equipamentos relacionados com inovação.
3. A proporção de trabalhadores que participam nas atividades de I&D da empresa.
4. O grau em que a empresa colabora com outros *players* inovadores suscetíveis de promover o mutualismo (como outras empresas ou institutos de investigação e desenvolvimento).
5. A capacidade de criar novas tecnologias com base em avanços técnicos.

6. A quantidade de novos bens, serviços ou redesigns que a empresa cria.
7. A quantidade de bens e serviços patenteados que a empresa possui.
8. A quantidade de bens e serviços licenciados que a empresa possui.
9. A proporção de iniciativas de investigação e desenvolvimento que atingem os seus objetivos e são consideradas bem-sucedidas.
10. A percentagem de vezes que a equipa de produção recebe atempadamente as especificações de um novo bem ou serviço.

11. A despesa média para cada projeto de investigação e desenvolvimento
12. As despesas de I&D ou de aquisição de novas tecnologias para cada novo produto, serviço ou remodelação.
13. Tempo médio gasto na criação de projetos de I&D.
14. A duração média do processo de ideação até o lançamento no mercado.
15. A proporção de bens e serviços que utilizam tecnologia recentemente adotada.

16. A proporção de tecnologia inovadora utilizada nos processos de produção.
17. O valor projetado das licenças e patentes da empresa.
18. A posição tecnológica e de inovação da empresa em comparação com os seus concorrentes.
19. A parte das vendas de novos produtos que a empresa gera.
20. A percentagem de despesas economizadas em resultado de novas tecnologias.

21. A parte dos ganhos atribuível à atividade relacionada com a inovação.
22. A parte do crescimento da quota de mercado que pode ser atribuída a iniciativas inovadoras.
23. A produtividade de I&D (em termos de ROI - Retorno do Investimento; ou da TIR - Taxa Interna de Rendibilidade.
24. A inovação conduz a uma diminuição das despesas de mão de obra.
25. Uma diminuição da utilização de materiais e de energia em resultado de perturbações.
26. Diminuição dos efeitos ambientais negativos das soluções inovadoras.

End of Block: P3

Start of Block: P4

Em que Unidade da empresa é que trabalha?

- ○ Serviços Regulamentares (SR)
- ○ Laboratórios (Lab)
- ○ Serviços de Engenharia (SE)
- ○ Formação (Form)
- ○ Unidade de Inovação (UI)
- ○ Laboratórios Especializados (LE)
- ○ Laboratórios de Ciências da Vida (LCV)

Há quantos anos trabalha no STP?

- ○ 5 anos ou menos
- ○ 6 anos - 10 anos
- ○ 11 anos - 15 anos
- ○ 16 anos - 20 anos
- ○ Mais de 20 anos

End of Block: P4

Start of Block: P5

Tem alguma sugestão ou correção para melhorar o nosso estudo? Por favor, escreva-as abaixo ou contacte-nos por email (56120@novasbe.pt).
O seu feedback é muito importante para nós e ajudar-nos-á a melhorar estudos futuros.

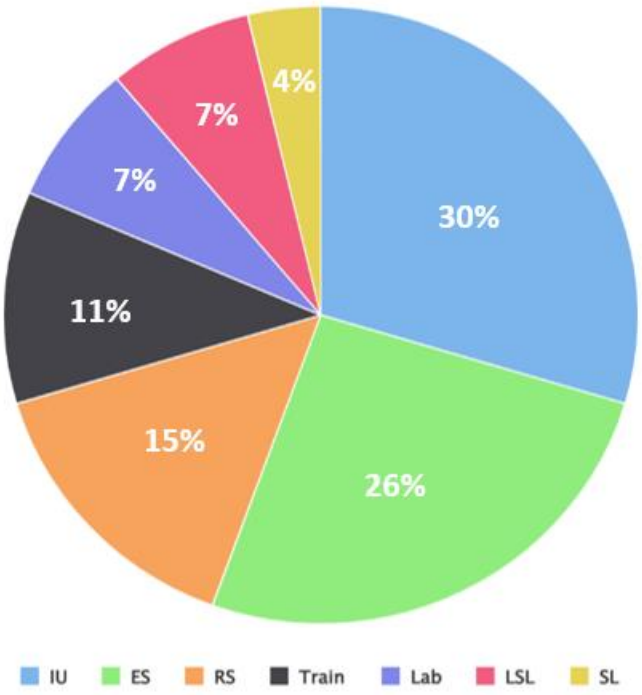
_____

End of Block: P5

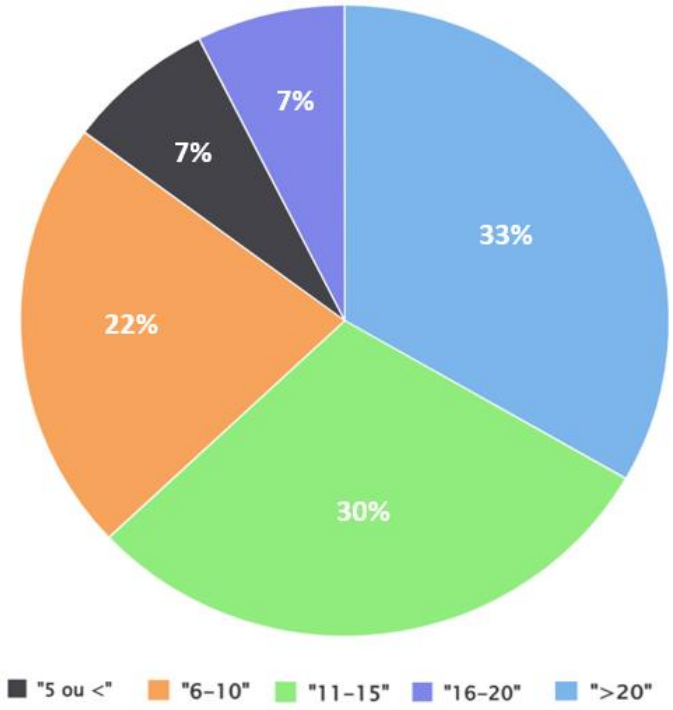
Appendix 12 - Studied KPIs description

No	Innovation KPI	Description
1	R&D Expenditure	A company's R&D expenditure to its revenue ratio.
2	Technical Improvement Expenditure	Making purchases of new equipment relating to innovation.
3	R&D Staff	The proportion of workers participating in the company's research and development activities.
4	External support	The degree to which the company collaborates with other innovative parties that might foster mutualism (such as other companies or research and development institutes).
5	Current Knowledge Owned	The capacity to create new technologies and concepts based on information gained and technical advancements.
6	Number of New Products/Services or Redesigns	The quantity of brand-new goods, services, or redesigns the business has created.
7	Number of Patents	The quantity of patented goods and services that the company has.
8	Number of Licenses	The quantity of licenced goods and services the company possesses.
9	Success Rate of R&D Projects	The proportion of research and development initiatives that meet their goals and are deemed successful.
10	On-time Delivery of Specifications to Manufacturing	The percentage of times the manufacturing team receives the specifications for a new good or service on time.
11	Average Cost of R&D Projects	The average financial outlay for every research and development project
12	R&D/Technology Acquisition Cost per New Product/Service or Redesign	The expenditure of R&D or purchasing new technology for each new product, service, or redesign.
13	Average Development Time of R&D Projects	Average time spent on the creation of R&D projects.
14	Average Total Time-to-market	The mean duration of the ideation to market launch process.
15	The Ratio of New Technology Applied in New Products	The proportion of goods and services that use recently adopted technology.
16	The Ratio of New Technology Applied in New Production Process	The proportion of innovative technology used in production processes.
17	The Potential Value of Patents and Licenses	The projected value of the business's licences and patents.
18	The Position of Firm's Technology and Innovation Comparing with Competitor	The inventive and technological standing of the company in comparison to its rivals.
19	New Sales Ratio	The portion of new product sales that the firm generates overall.
20	Cost Saving Ratio	The percentage of expenses saved as a result of new technology.
21	Percentage Profit due to R&D	The portion of earnings attributable to innovation-related activity.
22	Market Share Gained due to R&D	The share of the market share growth that may be attributed to innovative initiatives.
23	R&D Productivity	Research and development productivity (measured in terms of ROI - Return On Investment; or IRR - Internal Rate of Return).
24	Reduced Unit Labour Costs	Innovation leads to a decrease in labour expenses per unit.
25	Reduced Consumption of Materials and Energy	A decrease in material and energy usage due to disturbance.
26	Reduced Environmental Impacts	Lessening of innovative solutions' negative environmental effects.

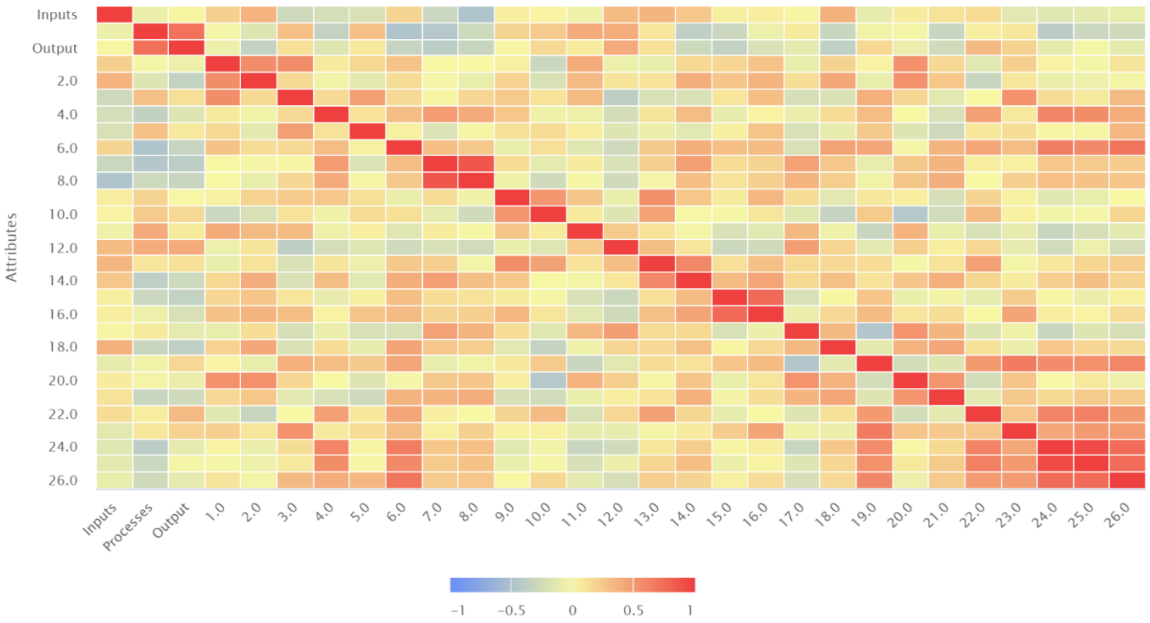
Appendix 13 - Descriptive data (by units)



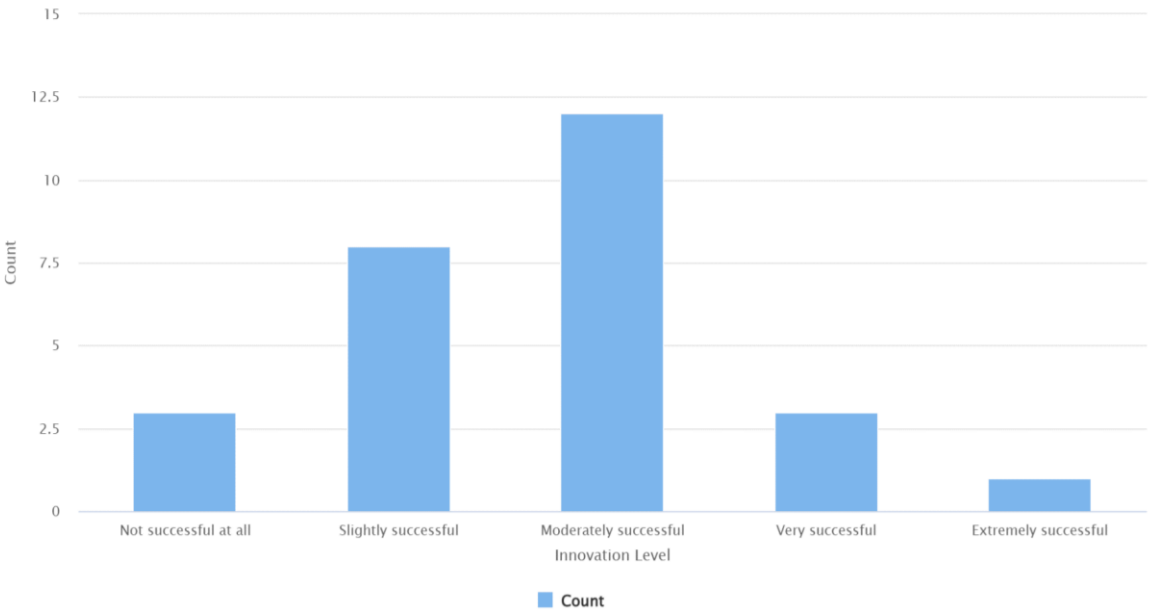
Appendix 14 - Descriptive data (by years in the company)



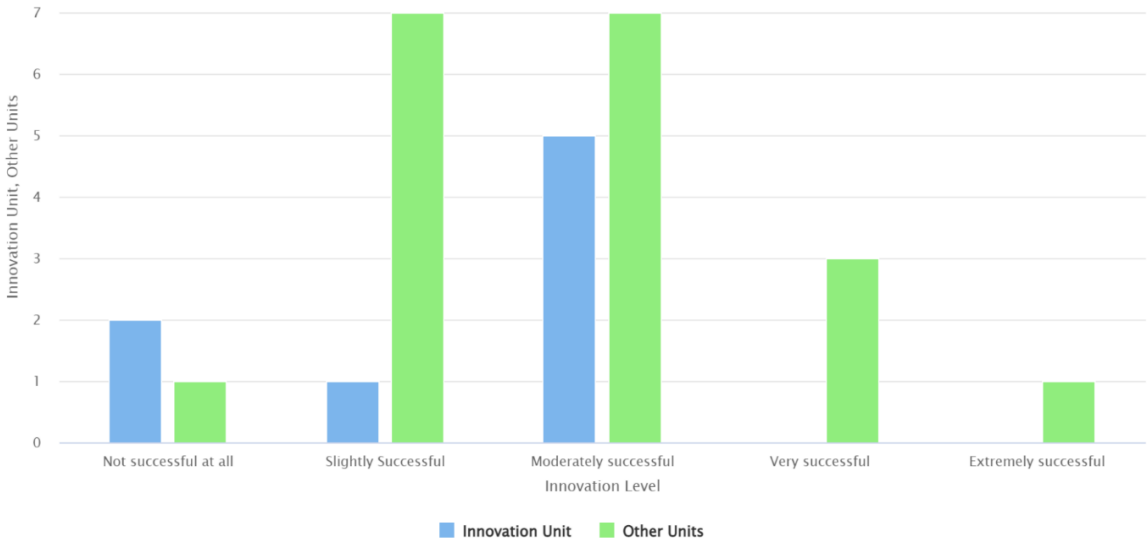
Appendix 15 - Correlation Matrix



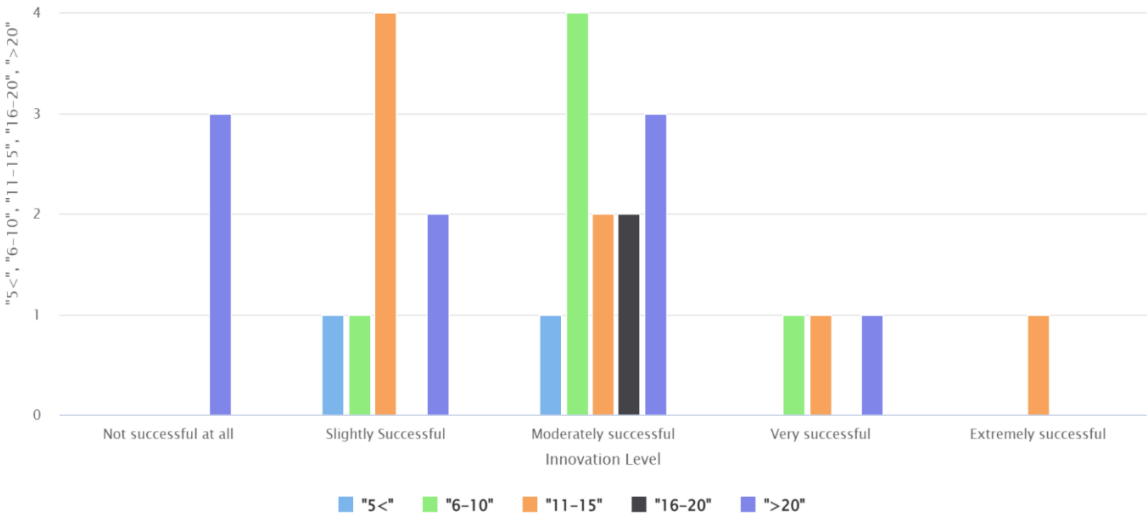
Appendix 16 - General innovation level



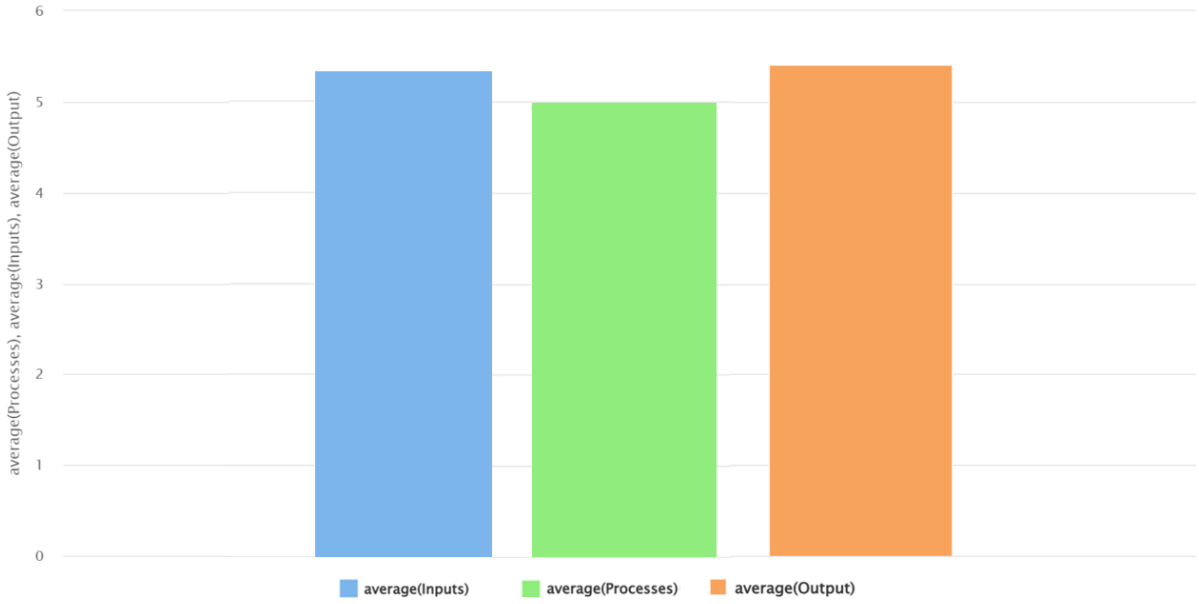
Appendix 17 - Innovation level by unit



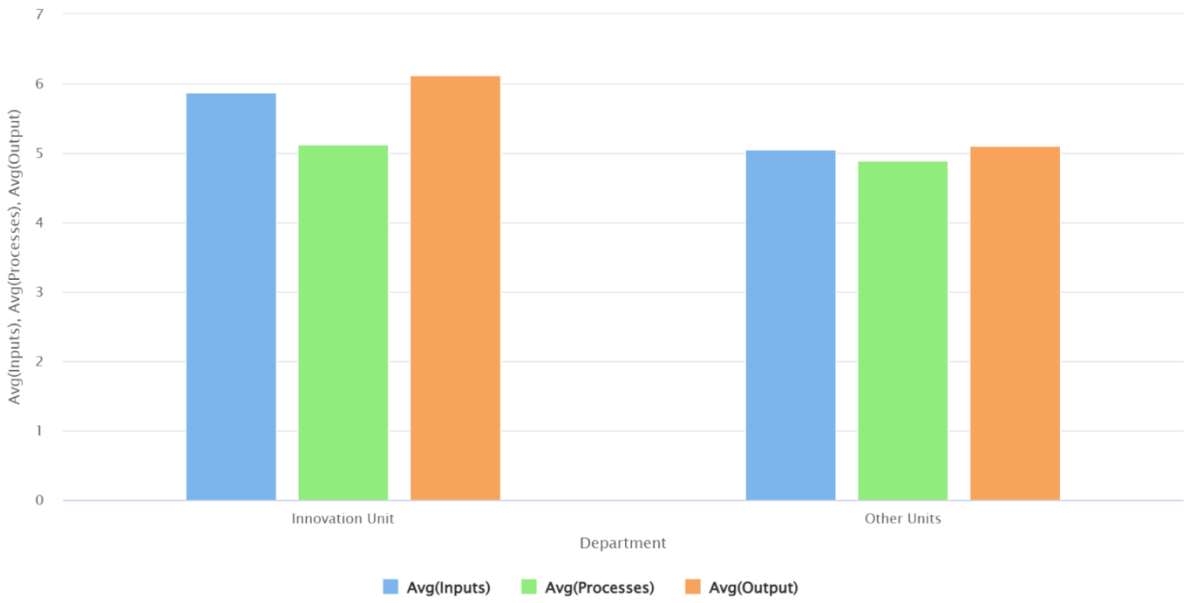
Appendix 18 - Innovation level by time working in the company (years)



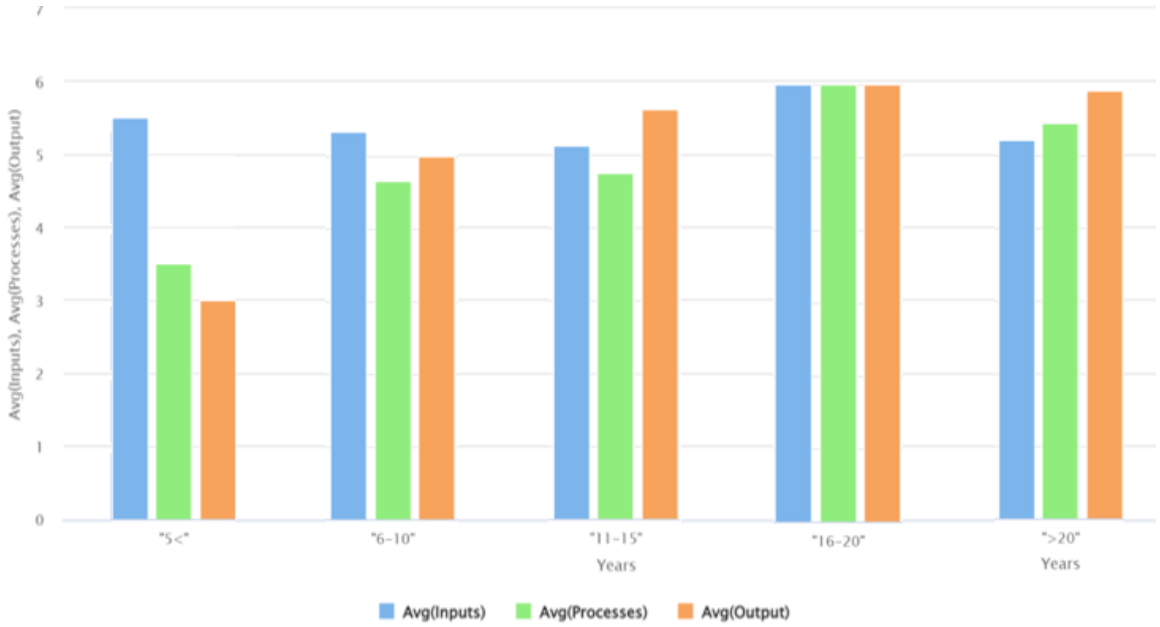
Appendix 19 - General measurement evaluation



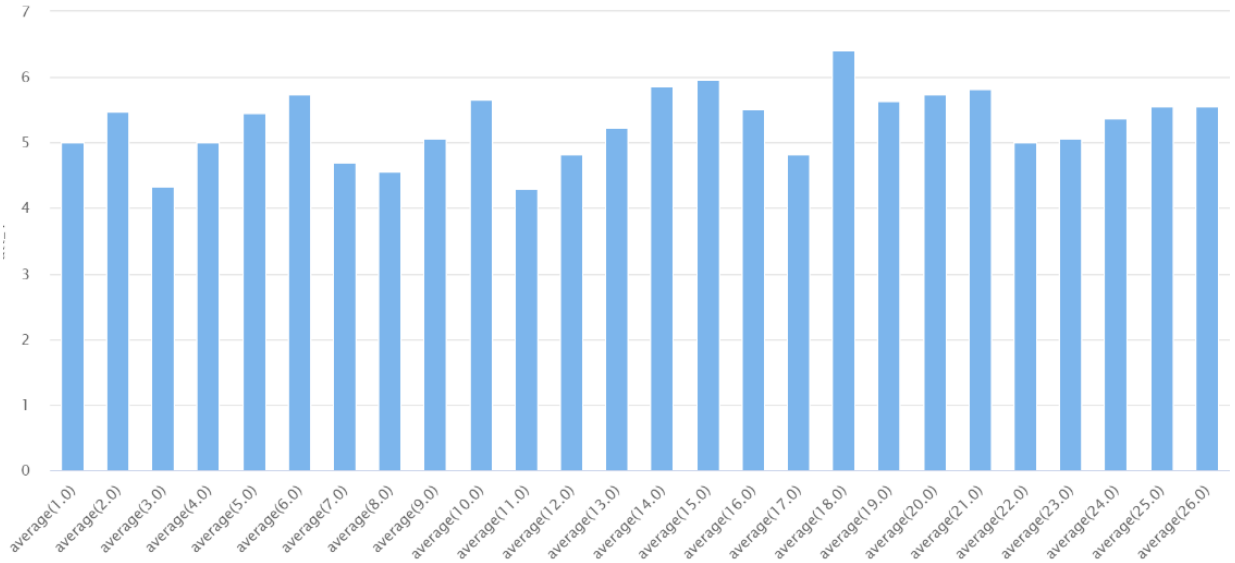
Appendix 20 - Measurement evaluation by Unit



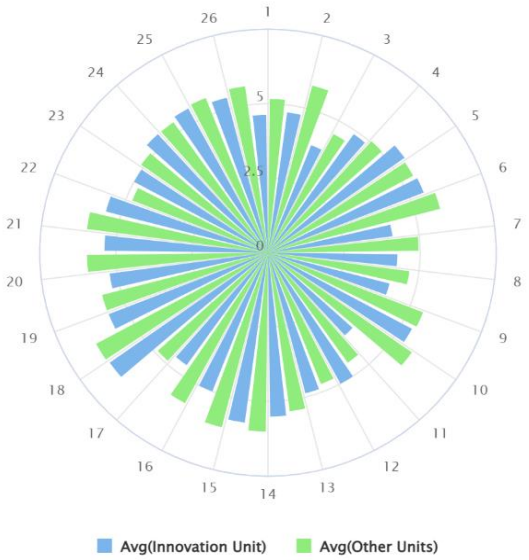
Appendix 21 - Measurement evaluation by time working in the company (years)



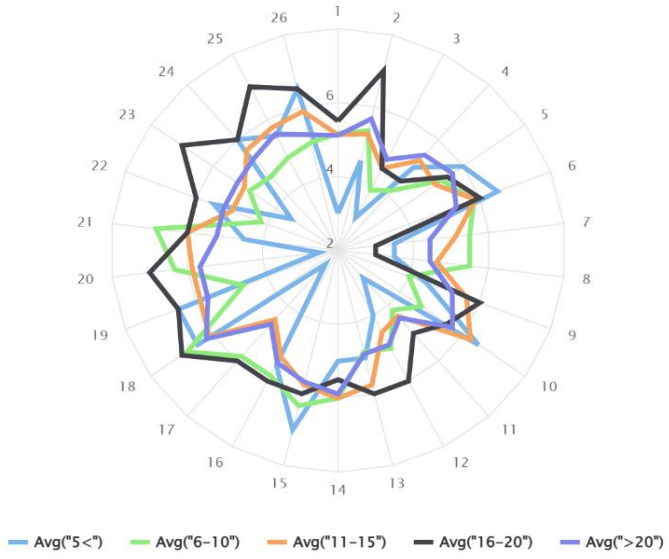
Appendix 22 - KPIs evaluation (Graph)



Appendix 23 - KPIs evaluation by unit



Appendix 24 - KPIs evaluation by time working in the company (years)



Appendix 25 - T-Test: Two-sample assuming unequal variances

	Innovation Unit	*Other Units*
Mean	5.034	5.403
Variance	0.418	0.220
Observations	8	19
t Stat	-1.461	
P(T<=t) one-tail	0.087	
t Critical one-tail	1.812	
P(T<=t) two-tail	0.175	
t Critical two-tail	2.228	

Appendix 26 - IU and Other Units difference and significance

KPI	Innovation Unit	Other Units	Δ	P-value
1	4.625	5.158	-53.3%	0.332
2	**4.750**	**5.789**	**-103.9%**	**0.024**
3	3.875	4.526	-65.1%	0.315
4	4.875	5.053	-17.8%	0.766
5	5.500	5.421	7.9%	0.877
6	5.500	5.842	-34.2%	0.409
7	4.125	4.947	-82.2%	0.320
8	4.250	4.684	-43.4%	0.564
9	4.125	5.474	-134.9%	0.085
10	5.375	5.789	-41.4%	0.440
11	3.750	4.526	-77.6%	0.114
12	5.000	4.737	26.3%	0.420
13	4.875	5.368	-49.3%	0.357
14	5.500	6.000	-50.0%	0.334
15	5.750	6.053	-30.3%	0.474
16	5.000	5.737	-73.7%	0.086
17	4.625	4.895	-27.0%	0.725
18	6.375	6.421	-4.6%	0.892
19	5.625	5.632	-0.7%	0.988
20	5.250	5.947	-69.7%	0.288
21	5.375	6.000	-62.5%	0.281
22	5.500	4.789	71.1%	0.195
23	5.000	5.105	-10.5%	0.881
24	5.375	5.368	0.7%	0.990
25	5.500	5.579	-7.9%	0.891
26	5.375	5.632	-25.7%	0.671

Appendix 27 - Highest rated KPIs' correlation

KPIs	**2.** Technical improvement expenditure	**14.** Average total time-to-market	**18.** The position of firm's technology and innovation compared to competitors
2. Technical improvement expenditure	1	0.403	0.437
14. Average total time-to-market	0.403	1	0.298
18. The position of firm's technology and innovation compared to competitors	0.437	0.298	1

Appendix 28 - KPIs Proposal. SMART Verification

	2. Technical improvement expenditure	**14. Average total time-to-market**	**18. Position of the firm's technology and innovation comparing to competitors**
Specific	Sets aside funding only for the improvement of technological and innovative procedures.	Measures the average time from R&D completion to product launch.	Compares the company's technological and innovative position to that of rivals.
Measurable	Can be measured by the tracking of costs associated with technological breakthroughs.	Quantifies the time required to bring a product or service to market.	Makes use of benchmarks or indexes to determine relative standing.
Attainable	Realistic investments aimed at improving current technology.	Timetables based on market demands and internal procedures are achievable.	It is possible to do this by investing in technology and innovation.
Relevant	Promotes innovation and efficiency, hence promoting corporate growth.	Critical for gaining a competitive edge and satisfying customer requirements quickly.	Aids in identifying opportunities for improvement and maintaining a competitive advantage.
Timely	Investments can be timely monitored to ensure they fit with technical demands and timetables	Can be timely monitored to reduce time-to-market and capitalise on possibilities.	Regularly monitored to keep current with technology breakthroughs and preserve a competitive edge.

Appendix 29 - KPIs Proposal. Lakiza (2018) Verification

Characteristics	Innovation Measurement System Proposal
Encouragement of initiative taking	Technical and innovation investment can be used to promote initiative by allocating funding for the improvement of procedures or systems. This may empower the personell to improve existing technology and procedures.
Focus on intangible aspects	The firm's positioning compared to competitors might help to focus on intangibles like technological capability, patent number, or inventive solutions. This can assist businesses in identifying emerging areas for improvement and maintaining a competitive advantage.
Focus on objective as opposed to results	Technical improvement expenditure may be used to focus on goals by tracking costs connected to technological breakthroughs. This can assist the company in ensuring that investments are following technology requirements and timetables.
Measurement of employee learning and continuous development	By quantifying the time required to bring products/services to market, the average total time-to-market can be used to monitor employee learning and continuous improvement. This can assist businesses in identifying areas where training or support has to be improved.
Focus on forecasting future processes as opposed to controlling past activities	By comparing the company's technological and innovation state with rivals, may be utilised to focus on projecting future processes. This can assist businesses in identifying areas where they need to improve to stay ahead of the competition.
Dynamic and flexible	These KPIs together can form a system that is flexible to changes in the market and the demands of the organisation, enabling better and resource allocation decision-making.
Informal and loose	The combination of these KPIs might result in a more casual approach to performance measurement. This can assist to develop an environment of creativity and experimentation which is beneficial to encouragment and new things trial.
Focus and strategy and vision as opposed to finance and controls	The KPI can form a more focused on the firm's long-term strategy and vision, putting aside the only financially-driven performance and controls. This can assist to ensure that the company is heading in the correct path and that resources are being allocated appropriately.

Appendix 30 - KPIs Proposal. Dewangan and Godse (2014) Verification

Principles	Innovation Measurement System Proposal
Be multi-dimensional	By adopting three differently-focused KPIs as a whole innovation monitoring system, we are ensuring that the evaluation covers several dimensions.
Evaluate stage's performance within the innovation cycle	The three differently-focused KPIs that include inputs, processes and outputs allow to cover all the steps of the innovation cycle with the proposed innovation monitoring system.
Address the objectives of organisational stakeholders	All three proposed KPIs are in line with meeting the goals of organisational stakeholders by allocating them to the improvement of processes.
Encourage a cause-and-effect-connection	The comparison with competitors' technological innovation, investment and time-to-market will lead to the strengthening of a causal relation of the processes.
Be simple to use and Implement	The three KPIs are straightforward to put into action which leads to the same once they are applied together as they do not overapply. To make them easier to monitor the periodicity can be the same of the already existing corporate objectives.