Optimisation of the decision-making process of investment in public projects through the use of practices of portfolio management

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Abstract: This article aims to explore the portfolio management tools and techniques that can assist policy makers to improve the quality of public spending. The researchers were motivated by Brazil being a country that provides one of the worst returns of taxes collected for the well-being of society [IBPT, (2013), p.2]. Several studies have shown the tools and techniques for portfolio management can improve the performance of organisations. The article was written in the form of a theoretical study, using descriptive and bibliographic research. The study sought to identify the best practices existing on portfolio management to describe a basic model that can be deployed in any public organisation.

Keywords: public spending; portfolio management; decision-making; prioritisation; public budget.

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1 Introduction

The quest for effectiveness of investment in public projects is a duty of the public manager, who has considerable budgetary resources from the efforts of Brazilian citizens. For that reason, portfolio management knowledge is an asset to the government.

Research conducted by Gemünden et al. (2013, p.11) in over 200 large and medium-sized enterprises in Germany, Switzerland, and Austria showed high-performance organisations have processes to prioritise projects formally established and with clearly defined rules, which contributes to their effectiveness.

A similar result can be found in *Pulse of the Profession: Portfolio Management* [PMI, (2014), p.8], where less effective organisations in project portfolio management reported experiencing three times more variations in their practices of prioritisation of projects (57%) in relation to the most effective organisations (16%), which shows a direct correlation between defined procedures, formalised with clear rules, and success in selecting projects.

In the same research, it was found that 63% of the more effective organisations in portfolio management use formal tools for projects prioritisation, while in less effective organisations, the percentage is only 13% [PMI, (2014), p.8].

This leads to a greater understanding about the relevance of project management in organisations, as demonstrated in PMI (2016, p.7), which identifies that 71% of high performance organisations understand the importance of project management compare to only 52% of poor performance organisations.

Using portfolio management could contribute to the optimal solution of portfolio composition in public organisations and assist managers in decision-making on public spending, which would lead to the complete care of the principles of the public interest's unavailability and efficiency, since the particular preferences of managers would be reduced due to the use of a formal and rational decision-making process about which projects would receive public resources for execution.

The optimisation of portfolio composition would allow the manager to maximise or minimise variables considered in the decision-making process of investment in public projects; the public manager could increase the portfolio benefits through the selection of those projects that most contribute to the organisational strategic objectives.

Along the same lines, other variables could be imposed on a mathematical model to find the best answer to the problem. Variables such as income generation, number of jobs generated, risk limit, deadlines, and a multitude of variables used by public managers for decision-making of investment could be inserted into the equation to obtain a better response within the scenario.

Using well-defined methods and criteria for project prioritisation could increase the public organisation maturity level in project management, since it would remove decisions based on subjective or particular concepts. This will make room for improved choices of well-structured projects and will contribute to the success of strategic management at those organisations. It is necessary to identify the best practices on portfolio management to allow the public manager to introduce those practices in their organisation if they are not an expert in the field. Therefore, this article intends to answer this question and identify the best practices in portfolio management and discuss the process to apply it to public organisations.

2 Literature review

The study of the effectiveness in public projects investment decisions by public organisations requires a preliminary analysis of fundamental concepts about the Brazilian administrative legal regime and current portfolio management best practices.

2.1 Fundamental principles of public administration

The Brazilian public administration is governed by several fundamental principles, which establish guidelines and give logical sense, harmony, and rationale to the administrative system [Alexandrino and Paulo, (2012), p.185].

The principles can be implicit or explicit; the most important are the principles of legality, impersonality, morality, publicity, efficiency, ample defense, contradictory, legal security, and public interest [Alexandrino and Paulo, (2012), p.185]. Among the principles set out, two apply directly to the study proposed in this article, precisely, the principles of public interest and efficiency.

One of the guiding principles of the Brazilian administrative legal regime is the unavailability of public interest, which applies restrictions and limitations on how a public manager can act [Alexandrino and Paulo, (2012), p.185]. Applying this principle means the public manager must apply public resources under his tutelage with the goal of serving the best public interest, according to the perspectives of the people (primary) and the state (secondary).

This public manager's duty to act on the application of public resources is also guided by the principle of efficiency, which results from the principle of the unavailability of public interest.

The principle of efficiency is provided in the caput of article 37 of the Brazilian Federal Constitution. This principle was added to Magna Carta through the constitutional amendment 19/1998, which introduced concepts of managerial administration to the constitutional text [Alexandrino and Paulo, (2012), p.201].

According to Alexandrino and Paulo (2012, p.201), the principle of efficiency has two aspects:

- "regarding the form of conduct of public agent, is expected the best performance of their duties, in order to obtain the best results".
- "on how to organise, structure and discipline the public administration, it is required that this be as rational as possible, in order to achieve better results in the provision of public services".

Unfolding the aspects of the efficiency principle on the topic under study denotes the importance of using appropriate tools to assist public managers in conducting their daily activities, such as decision-making on investment for public projects. Another consequence of the efficiency principle is the need of public administration to have clear and well-defined processes and to conduct the businesses of the State efficiently.

2.2 Portfolio management

The standard ISO 21.504:2005 project, program, and portfolio management – guidance on portfolio management [British Standard Institution, (2005), p.2] states, "portfolio

management should include a set of interrelated organisational processes and methods by which an organisation allocates resources to implement its strategic objectives" and it aligns the portfolio components with strategic objectives, stakeholder priorities, and values.

The MoP guide – management of portfolio defines portfolio management as "a coordinated collection of strategic processes and decisions that together enable the most effective balance of organisational change and business as usual" [OGC, (2011), p.11].

Portfolio management is defined by PMI (2013a, p.5) as the "coordinated management of one or more portfolios to achieve organisational strategies and objectives". The Project Management Institute completes the concept clarifying this discipline includes interrelated processes by which an organisation evaluates, selects, prioritises, and allocates the organisational resources to ensure the success of strategy implementation in alignment with the vision, mission, and values of the organisation.

Rad and Levin (2006, p.10), in turn, define portfolio management as a "dynamic decision-making process, whereby a business' list of active projects is constantly updated and revised". The authors explain that, during portfolio management, new projects are evaluated, selected, and prioritised, while existing projects are accelerated, finished, or deprioritised and, because of that, resources are allocated and reallocated to all active projects.

Levine (2005, p.1) presents a broader view of the discipline when conceptualising portfolio management, arguing "project portfolio management is a set of business practices that brings the world of projects into tight integration with other business operations. It brings projects into harmony with the strategies, resources, and executive oversight of the enterprise and provides the structure and processes for project portfolio governance".

Rajegopal et al. (2007, p.11) briefly define portfolio management as a collection of projects and programs in which an organisation invests to implement a particular strategy.

From the portfolio management concepts presented, some basic features on the topic can be extracted:

- Composition: all authors unanimously list the projects and programs as basic components of a portfolio. The PMI (2013a, p.5), in turn, adds organisational processes as members of the portfolio, trying to give the portfolio concept a more integrated vision between the world of projects and processes.
- Strategy: the link with the organisational strategy is a constant on the concepts about portfolio management, clarifying that this is an appropriate way to implement the organisation's strategy.
- Practices: some good practices are derived directly from the concept of portfolio management, such as assessment, prioritisation, and selection.
- Resources: most authors relate portfolio management to improvements in the employment of organisational resources, be they financial, human, or material.

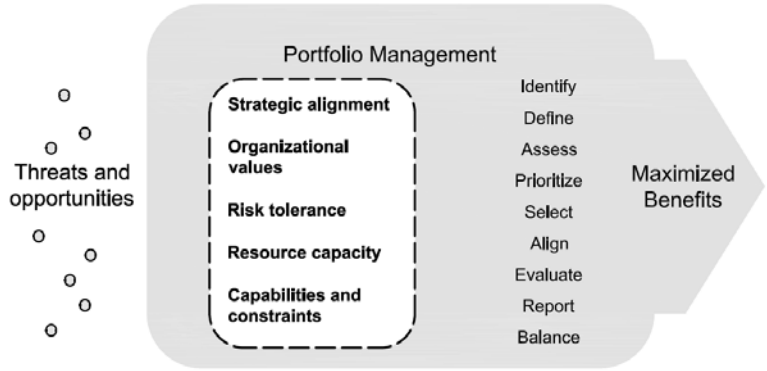
In summary, portfolio management is an important element of the strategy execution framework, given it "aligns with organisational strategies by selecting the right programs or projects, prioritising the work, and providing the needed resources, whereas program management harmonises its projects and program components and control

independencies in order to realise specific benefits" [PMI, (2013a), p.7]. Project management develops and implements the projects driven by directives of the portfolio or program. The link between portfolio, program, and project management highlight that they "differ in the way each contributes to the achievement of strategic goals", although they are all aligned or driven by the organisation's strategic objectives. In this article, the focus relies on the portfolio management practices.

2.2.1 ISO 21.504:2005 – guidance on portfolio management

The ISO 21.504:2005 is an international standard that provides guidance on the principles of portfolio management to private and public organisations. The standard states, "to build and manage a portfolio effectively, portfolio components should be continuously identified, evaluated, selected, and authorised; and a status and performance of the portfolio regularly reported. Further, continuous alignment of the portfolio with business strategies and objectives as well as evaluation and control of the balance of the portfolio against a number of criteria should be maintained", as it illustrates in Figure 1.

Figure 1 A view of portfolio management according to ISO 21.504:2005



Source: British Standard Institution (2005, p.3)

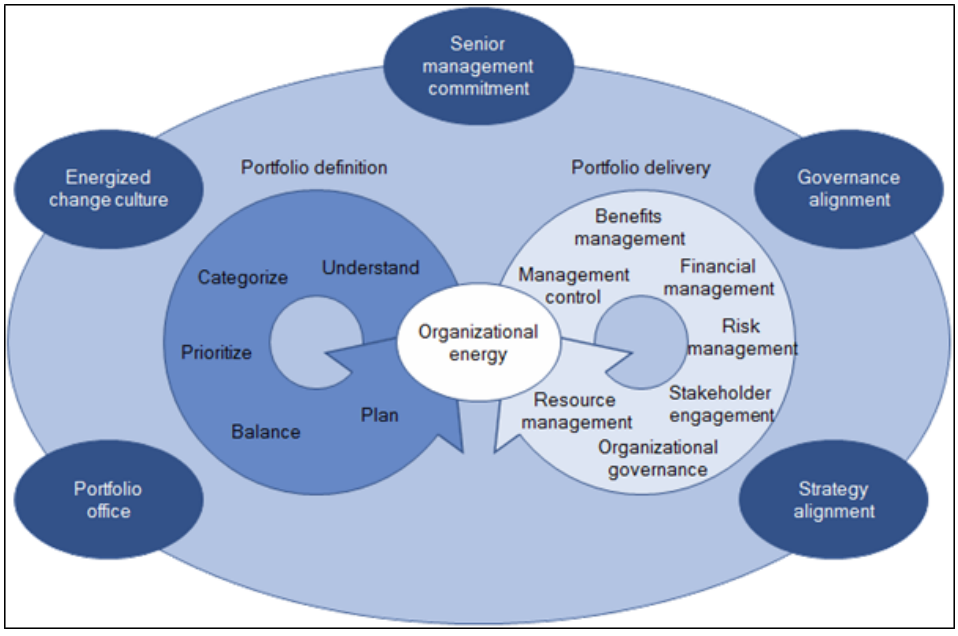
The view of portfolio management presented by the ISO 21.504:2005 and illustrated in Figure 1 is driven by several processes, namely, defining the portfolio, identifying potential portfolio components, defining the portfolio plan, assessing and selecting portfolio components, validating portfolio alignment to strategic objectives, evaluating and reporting portfolio performance, and balancing and optimising the portfolio:

- Defining the portfolio: this process is related to the objectives of the portfolio, helping to define what can be set to different periods, considering the constraints, capabilities, risk tolerance, and values [British Standard Institution, (2005), p.7].
- Identifying potential portfolio components: it is a continuous process that views the selected and potential components and maps it against the organisation's strategic objectives [British Standard Institution, (2005), p.7].
- Defining the portfolio plan: a process that develops a plan regarding the existing and potential portfolio components, its targeted benefits, costs, timescales, and the interdependencies between them [British Standard Institution, (2005), p.7].

- Assessing and selecting portfolio components: this process categorises, evaluates, selects, aligns, authorises, and prioritises the portfolio components to balance the portfolio and maximise the probability of achieving the organisational objectives [British Standard Institution, (2005), p.8].
- Validating portfolio alignment to strategic objectives: this process keeps the continuous alignment with the organisation's strategic objectives, maintains the alignment with risk tolerances and organisational resource capacity and capabilities, and documents and evaluates results of the alignment actions [British Standard Institution, (2005), p.9].
- Evaluating and reporting portfolio performance: it is a continuous oversight of the portfolio, executing four main actions, namely, establishing the portfolio performance measurement baseline, managing portfolio performance, reporting portfolio performance, and managing the integration of benefits [British Standard Institution, (2005), p.10]
- Balancing and optimising the portfolio: this process makes the adjustments while implementing the portfolio's projects and programs. The main activities executed are the optimisation of portfolio components, maintenance of the portfolio, optimisation of resources, management of portfolio risks, and control of portfolio change [British Standard Institution, (2005), pp.11–12].

The ISO 21.504:2005 presents generic principles of portfolio management used by other standard and methods, such as the MoP guide – management of portfolios and the PMI's standard for portfolio management, presented in the following sections.

Figure 2 Portfolio management principles, cycles and practices (see online version for colours)



Source: Adapted from OGC (2011)

2.2.2 MoP guide – management of portfolios

The MoP guide is a portfolio management method with the purpose of giving guidance to practitioners through "universally applicable principles and practices that will enable individuals and organisations (large and small) to successfully introduce or re-energise portfolio management approaches". Different from ISO 21.504:2005 and PMI's standard for portfolio management, although compatible regarding practices, the MoP guide defines the processes, the governance organisation, templates, checklists, roles, and responsibilities. The method is structured by five principles, two cycles, and 12 practices, as illustrated in Figure 1.

The external circles in Figure 1 illustrate the five portfolio management principles that, according to OGC (2011, p.27), "represent the foundation upon which effective portfolio management is built". The portfolio management principles are the senior management commitment, the governance alignment, the strategy alignment, the portfolio office, and the energised change culture, and their key ideas to success are:

- Senior management commitment: proactive and visible senior management commitment is the central idea in this principle, which defines the keys to success as the existence of a senior management champion, clearly defined roles, responsibilities and accountabilities, active engagement, a compelling vision and alignment with the reward, and recognition strategies [OGC, (2011), p.28].
- Governance alignment: "the successful implantation of portfolio management is effective governance" [OGC, (2011), p.29] and the keys to success of this principle are clearly defined roles, responsibilities and accountabilities, portfolio governance consistent with the wider organisation governance structure, shared understanding, an agreed escalation process, aligned meeting schedules, and sub-portfolios periodically reviewed by organisational portfolio governance body [OGC, (2011), p.32].
- Strategy alignment: this principle focus on the facilitation to achievement of the organisation's strategic objective. The keys to success, according to this principle, are "strategic objectives are supported by driver-based analysis, benefits are clearly and consistently identified, collaborative working, regular review at a portfolio level, regular review at an initiative level and early involvement improves quality" [OGC, (2011), p.37].
- Portfolio office: this process argues the "portfolio management enables the relevant portfolio governance bodies to make better and more informed investment decisions" [OGC, (2011), p.38], so a physical or virtual office must deal with these matters. The key to success, according to this principle, are the organisational status, an agreed mandate, collaborative working, appropriate skills, and regular measurement of progress [OGC, (2011), p.40].
- Energises change culture: this process states an effective portfolio management can be realised only "if people working for the organisation are engaged, focused on the appropriated goals and feel a sense of working together as one team" [OGC, (2011), p.41], and the keys to success are "collaborative working, proactive communications, a learning organisation, clarity about expectations, effective processes, roles and relationships agreed with a clear line of sight from strategic to personal objectives,

monitoring of organisation energy, demonstrable senior management commitment, listening and engagement" [OGC, (2011), p.42].

Table 1 Portfolio management practices

Item	*Cycle*	*Practice*	*Purpose*
1	Definition	Understand	Obtain a clear and transparent view of what is in the current portfolio and the project development pipeline, performance to date and, looking forward, the forecast costs, benefits, risks to delivery, and benefits realisation.
2		Categorise	Categorisation organises change initiatives into groups, segments, or sub-portfolios based on the strategic objectives or other grouping as required.
3		Prioritise	Prioritising ranks the change initiatives within the portfolio (or portfolio segments) based on one or more agreed measures.
4		Balance	Ensure the resulting portfolio is balanced in terms of factors, such as timing, coverage of all strategic objectives, impact across the business, stage of initiative development, overall risk/return profile, and available resources.
5		Plan	Collate information from the portfolio definition cycle and create a portfolio strategy and delivery plan approved by the portfolio direction group/investment committee.
6	Delivery	Management control	Ensure progress, at an individual and portfolio level, is regularly monitored against this baseline.
7		Benefits management	Clearly identify and manage the benefits realised from the portfolio, helping to ensure the best use of available resources and the contribution to operational performance and strategic objectives is maximised.
8		Financial management	Ensure the portfolio management processes and decisions are aligned to the financial management cycle and financial considerations from a key element in all decisions regarding the commencement and ongoing viability of change initiatives, both at an individual and at a collective level.
9		Risk management	Ensure consistent and effective management of the portfolio's exposure to risk at both individual and collective level.
10		Stakeholder engagement	Provide a coordinated approach to stakeholder engagement and communication.
11		Organisational governance	Ensure clarity about what decisions are made, where and when, and what criteria are used.
12		Resource management	Put in place mechanisms to understand and manage the resources available and required.

Source: Adapted from OGC (2011, pp.51–93)

The second component of the portfolio management method are the portfolio management cycles, divided into portfolio definition and portfolio delivery and linked by the organisational energy element illustrated in Figure 1. The guide argues, "the purpose of the portfolio delivery cycle is to ensure the successful implementation of the planned

change initiatives as agreed in the portfolio strategy and delivery plan, whilst also ensuring that the portfolio adapts to changes in the strategic objectives, project and program delivery and lessons learned" [OGC, (2011), p.48]. The organisational energy is the link between the two cycle, and it is defined by "the extent to which an organisation has mobilised its emotional, cognitive and behavioural potential to pursuit its goals" [OGC, (2011), p.131].

The third and last part of the portfolio management method in the MoP guide are the practices, divided into the two portfolio management cycles, specifically five in the definition cycle and seven in the delivery cycle, as summarised in Table 1.

The combination of principles, cycles, and practices in the MoP guide builds consistent guidance to the management of portfolios. Several practices and keys to success are compatible with processes and concepts in the ISO 21.504:2005 or in the PMIs standard for portfolio management.

2.2.3 PMIs standard for portfolio management

The PMIs standard for portfolio management is a body of knowledge that indicates several good practices on portfolio management, including knowledge, processes, skills, tools, and techniques. It divides the processes into three groups, namely, defining, aligning, and authorising and controlling [PMI, (2013a), p.31].

PMI (2013a, p.31) explains the defining process group lies mainly at the junction of the processes performed to define how the organisational goals and strategies will be executed through portfolio. The group also involves the processes to define the portfolio strategic plan, determine the framework and portfolio flows, define and authorise the portfolio or sub-portfolio, and develop the portfolio management and auxiliary plans.

The defining process group is responsible for the composition of the portfolio of the organisation, since this is the group responsible for the major planning activities. The defining process group has a direct relation with strategic planning activities, as these processes are perfectly integrated, and they occur more actively when reviewing the objectives and strategies of the organisation.

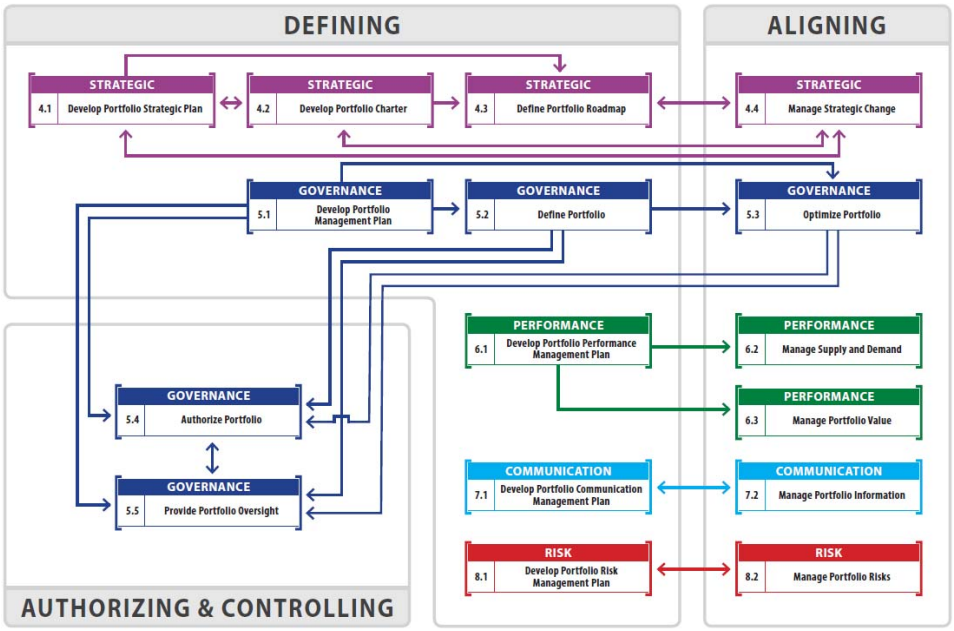
Once the organisation's portfolio is established, the aligning process group goes into action. This group handles the categorisation, evaluation, selection, modification, disposal, and portfolio management [PMI, (2013a), p.32]. In this article, the alignment process group is the main element of research.

The third portfolio collection of processes is the authorising and controlling group, with the objective to define how the portfolio will be authorised and controlled. The activities carried out by this set of processes are responsible for monitoring the changes in strategy, observing and reviewing the key performance indicators to ensure strategic alignment, for the authorisation of the portfolio components, and for verification of the value added to the organisation [PMI, (2013a), p.32].

The process groups work in a continuous and iterative way, adapting changes to the organisation's portfolio that may occur. These fine adjustments promoted by the portfolio management processes ensure the best return on investments and the better use of organisational assets.

The portfolio management areas are composed of processes that deal with similar themes that permeate all process groups presented previously. Vargas and Maxsen (2013) illustrate the processes, knowledge areas, and process groups through a flow chart, shown in Figure 3.

Figure 3 Portfolio management processes flow (see online version for colours)



Source: Vargas and Maxsen (2013)

As seen in Figure 3, the portfolio management knowledge areas are strategic, governance, performance, communications, and risk.

The portfolio strategic management area includes the processes responsible for developing the portfolio strategic plan, the portfolio charter, the roadmap, and the strategic change management process [PMI, (2013a), p.41].

The portfolio governance management area aims to ensure the analysis of the investment is held to identify threats and opportunities, any changes, dependencies and impacts are evaluated, the portfolio is selected and prioritised, and the financing activities are scheduled to reach the designed objectives [PMI, (2013a), p.57].

To fulfil its objective, the portfolio governance management team uses the processes to develop the portfolio management plan, define, optimise, authorise, and provide portfolio oversight [PMI, (2013a), p.57].

The portfolio performance management knowledge area determines the best composition of the portfolio and a thorough sequence of projects to ensure the achievement of the objectives and organisational strategies. The processes that compose the performance management execute planning, mediation, and monitoring of the portfolio benefits in relation to the outlined objectives [PMI, (2013a), p.85].

The processes that compose portfolio performance management are the development of the portfolio performance management plan, the supply and demands management, and the portfolio value management [PMI, (2013a), p.86].

The portfolio communication management knowledge area is focused on satisfying the stakeholders' information requirements, so they can make more assertive decisions, so strategic objectives can be achieved and communication-related risks can be mitigated. The processes that support this knowledge area are the development of the

communications management plan and portfolio information management [PMI, (2013a), p.105].

Risk management is the last portfolio management knowledge area and is structured to perform the assessment and analysis of risks related to the portfolio to capture opportunities (positive risk) or mitigate threats (negative risk) [PMI, (2013a), p.119].

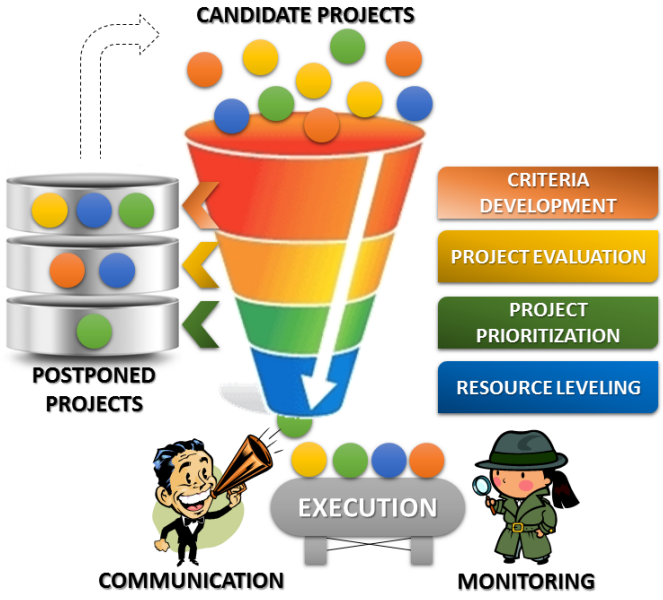
The processes that compose the portfolio risk management knowledge area are the development of the portfolio risk management plan and management of portfolio risks [PMI, (2013a), p.121].

The combination of processes groups, portfolio management knowledge areas, and portfolio management processes forms a robust body of knowledge that must be adapted, and a method must be created by the organisation that wants to put these processes in practice. All these processes have a correlated practice or principle in the other standards and methods presented, namely the ISO 21.504:2005 and the MoP guide, and the organisations can combine and use these standards and methods to developed its own portfolio management method.

3 Discussion

The main best portfolio management standards and methods in the literature review section are the ISO 21.504:2005 (British Standard Institution, 2005), the MoP guide (OGC, 2011), and the PMIs standard for portfolio management (PMI, 2013a). Regardless of the choice made by organisations, most of these practices are present in both textbooks and are almost obligatory compliance factors for organisations. A portfolio prioritisation methodology can be visualised as shown in Figure 4.

Figure 4 Portfolio prioritisation (see online version for colours)



Source: Author

As noted in Figure 4, there are four major groups of activities performed during the portfolio prioritisation process, namely, criteria development for evaluation of the portfolio, the assessment of candidate projects, prioritisation of initiatives and, finally, the levelling of resources to be used.

It is observed that, after the resource levelling, the project's implementation begins, and opportunities in which the communication and monitoring group processes come into action. In this article, only the main four groups of activities will be discussed, given its focus on optimisation.

3.1 Development of evaluation criteria

Developing the criteria by which the portfolio components will be evaluated pass through two important processes, the identification of the criteria used by decision makers and the establishment of weights between the variables used.

3.1.1 Criteria identification

The identification of the criteria adopted by decision makers, even when held directly with decision makers, is better structured if based on a list of criteria widely used by organisations. According to PMI (2013a, p.68), some criteria that can be adopted are profit increase, risk reduction, efficiency improvement, the need for legal compliance, market share increase, continuous improvement, process improvement, and business imperatives.

Among the criteria singled out by PMI (2013a, p.68), all of them can be used by the public administration, whereby only a few adjustments are required, regarding the interpretation for each criterion.

The public administration is not intended to profit, but to provide public goods to society. In this monetary context, public organisations work under a logic of increasing budgetary capacity, through increased relative participation in the government's budget or by economic exploitation of public goods transferred to individuals and seek the reduction of operating costs.

The increase in market share can be interpreted as an increase of the state presence in the provision of public services to society, and this increase in market share does not represent competition with the private sector.

Several other criteria may be adopted by public managers. Thiry (2003, pp.1–3) explains most organisations employ financial criteria for project evaluation. This preference for financial criteria, also supported by Bullivant et al. (2008, p.4), occurs, in part, by the quantitative nature of these variables; however, there are criteria that can only be described through qualitative vectors.

As evaluation criteria of the portfolio components, Thiry (2003, pp.1–3) also proposed the generation of variables benefits by project or program and the feasibility of these initiatives. The author bases this on the idea that stakeholders establish and measure success according to the expected benefits, so it would be logical to prioritise initiatives based on that premise. Another point the author considers is that not all initiatives proposed are achievable, so this also needs to be considered.

Jung and Lim (2007, p.56) explain the decision makers may still use criteria such as the project's consistency with the mission and organisational objectives, the contribution

to the strategic objectives, the balance between projects of long- and short-term, and the impact on cash flow and resource consumption.

Modica et al. (2010, p.4) feature a case study where the criteria for portfolio prioritisation were operational safety, operational processes, customer satisfaction, finances impact, influence over image and brand name of the company, legal and regulatory provisions and complexity, and the multidisciplinary nature of the initiatives.

In research conducted by Enoch (2010, p.14) in several organisations in South Africa, the author obtained a list of the main criteria adopted in that country. In that case, the managers were making investment decisions based on the project's strategic relationship, the impact on organisational efficiency, financial and employment capabilities to implement the solution, the need for legal compliance, the project's complexity, the needs and benefits for the organisation, and financial criteria, such as internal rate of return (IRR), return on investment (ROI), and net present value (NPV).

Wilson (1997) presents a case where time-related criteria, direct return on the organisational finance, such as cost savings or revenue increment, and indirect benefits, such as increasing the technological efficiency or productivity, were adopted to prioritise the portfolio.

Knutson and Gump (1996, p.3) claim there are mandatory criteria, where the negative assessment should result in the exclusion of the following evaluation phases. In the author's opinion, criteria such as relation with the organisational mission and no conflict with organisational values are factors of exclusion of the project in the prioritisation process.

The numbers of criteria that can be used are immense; however, the public organisation must identify which ones relate to the internal process for portfolio prioritisation. Financial criteria, usually related to the business world, do not fully apply to public administration. In these cases, the manager can adjust the criteria or adopt different approaches, for example, the value for money (Audit Commission et al., 2010), or the social return on investment (The SROI Network, 2012).

3.1.2 Criteria weighting

The weighting of the criteria identified is one technique described by PMI (2013a, p.68) through the tool entitled analytic hierarchy process (AHP). The AHP consists of the comparison of decision variables to develop a relative scale of contribution between the criteria being compared.

Thibadeau (2007, p.1) provides the axioms that direct the methodology developed by Saaty:

- reciprocal comparison: if A is x times more preferred than B, then B is 1/x times preferred than A
- uniformity: the preferences are established based on a certain scale
- independence: with the establishment of preferences, the criteria are assumed to be independent of each other
- expectations: the hierarchical structure developed is perfectly capable of explaining the model used for decision-making.

The comparison proposed by the AHP can be performed through a binary scale, where, for example, criterion A receives one if it is preferred over B. The reciprocal is that B receives zero over A [PMI, (2013a), p.68]. The sensitivity of this binary range is smaller, as verified in the case study by Modica et al. (2010, p.4).

The authors [Thibadeau, (2007), p.3; Mustafa and Murphree, (1989), p.30; Mian and Dai, (1999), p.47; Vargas, (2010), p.4] prefer to use the scale proposed by Saaty, where the pairs are evaluated as described in Table 2.

Table 2 Saaty scale

Importance intensity	*Reciprocal*	*Definition*	*Explanation*
1	1	Equal importance	Two activities (A and B) are equally important to the objective
3	1/3	Moderately important	A and B: there is a slight difference of an activity on the other.
5	1/5	More important	A and B: there is a big difference of an activity on the other.
7	1/7	Much more important	A and B: there is a very large difference of an activity on the other.
9	1/9	Extremely important	A and B: there is an extreme difference of an activity on the other.
2, 4, 6, 8	1/2, 1/4, 1/6, 1/8	For harmonisation between the previous values	Sometimes there is a need to harmonise a trial numerically, because the proposed descriptions do not represent exactly the decision maker's desire

Figure 5 Decision-making example (see online version for colours)

Source: Author

In a public organisation that adopted the decision model based on the criteria identified in Figure 5, two analyses would be required, one for the first level categories and another one for the second level of criteria.

Adopting a technique of top-down decomposition, the first step for weighting the criteria would be the comparative analysis of the first level of variables, as demonstrated in Table 3.

Table 3 AHP matrix for the first level criteria

Criteria	*Strategic objectives*	*Cost-cutting*	*Risk*	*Operational efficiency*	*Total*	*%*
Strategic objectives	1	7	5	3	16	45.26
Cost-cutting	1/7	1	3	1/5	4.34	12.28
Risk	1/5	1/3	1	1/7	1.68	4.74
Operational efficiency	1/3	5	7	1	13.33	37.72
				Total	35.35	100

Source: Author

After the judgement of the first level of criteria, the process is repeated for the categories that contain sub-criteria, such as the strategic objectives outlined in Figure 5. To obtain the overall contribution of these sub-criteria, simply multiply the value found with the top category [Anbari, (2007), p.2].

The scale to be used to measure the weights of the criteria can be adapted depending on the approach the organisation adopts for the process. Modica et al. (2010, p.7), for example, used the Likert scale initially in his research.

Thiry (2003, p.5), in turn, used a nonlinear scale where the answers ranged from 0.625, 1.25, 2.5, 5.0, and 10. This scale, where it is possible to identify a larger gap between affirmations, can correct distortions caused by the sum of less significant items that can weigh the same or more than a very important criterion.

Table 4 presents an example of nonlinear scale based on Likert scales and on the scale proposed by Thiry (2003, p.5).

It is observed that the use of the main features of each scale allows the correction of distortions caused by the choice of linear methods and promotes a greater ease of use by public managers using positive and negative measures in a single scale.

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Table 4 Nonlinear scale for criteria evaluation

Score	*Reciprocal*	*Definition*
0.625	10	Much less important than
1.25	5	Less important than
2.5	2.5	As important as
5	1.25	More important than
10	0.625	Much more important than

Source: Adapted from Thiry (2003, p.5)

It is observed that the use of the main features of each scale allows the correction of distortions caused by the choice of linear methods and promotes a greater ease of use by public managers using positive and negative measures in a single scale.

3.2 Project evaluation

Developing the decision-making model based on the identified criteria and relative weight of each variable opens space for evaluating projects in relation to the contribution of the initiative in relation to the model drawn.

As an example of criteria weighting, the project assessment uses a scale capable of representing the contribution of the project to the benchmark.

Authors such as Modica et al. (2010, p.6), Mian and Dai (1999, p.50), Thibadeau (2007, p.6) and Thiry (2003, p.4) prefer to evaluate the projects directly in relation to the weighted criteria to develop a single array comprising projects and criteria. Vargas (2010, p.12), on the other hand, prefers to develop a matrix to compare each project regarding all the criteria, so the number of matrices is equal to the number of projects, and the size of each is directly proportional to the number of criteria.

As the number of projects and the decision criteria in public administration are very large, this study will use the approach preferred by most authors, even if the method proposed by Vargas (2010, p.12) is highly accurate. The choice of a very complex tool would ultimately discourage public managers during the evaluation process, as indicated in Jung and Lim (2007, p.56).

The prioritisation process phase uses a logarithmic scale and the comparison of decision criteria, as shown in Table 5.

Table 5 Nonlinear scale for project contribution assessment

Score	*Definition*
0.625	Very low
1.25	Low
2.5	Average
5	High
10	Very high

Source: Adapted from Thiry (2003, p.5)

Unlike the scale for analysis of decision criteria, the measure for evaluation of projects does not have reciprocal value, since it is not a comparison, but only an indication of a contribution to the composition of the criterion evaluated.

Another difference is the scale for evaluating projects is not a measure of preference, though it is needed to detail the degree of contribution to allow a proper assessment of the initiatives. Using the decision-making model in Figure 5, evaluating a project about the prospect of reducing costs, for example, is very relative, because each person has their own understanding of cost-cutting. For one manager, it could be a measure of the order of 50%, and for another, it could be 70%.

These subjectivities in the trial require the development of a guide to support the evaluation, as exemplified in Table 6.

Table 6 Example of support guide to project contribution evaluation

Criteria: cost-cutting		
Score	*Definition*	*Description*
0.625	Very low	The project is able to reduce operating costs by up to 5%
1.25	Low	The project is able to reduce operating costs by up to 10%
2.5	Average	The project is able to reduce operating costs by up to 20%
5	High	The project is able to reduce operating costs by up to 50%
10	Very high	The project is able to reduce operating costs in 70% or more

Source: Author

When developing the model for the project evaluation, it is up to the manager to perform the analysis for each initiative in relation to the weighted criteria. This results in an array as shown in Table 7.

Table 7 Project evaluation matrix

Weight / *Candidate*	*Criteria 1*	...	*Total Score*	*Contribution*
	13%	...	...	...
Project A	Very high (10 × 13%)	...	1.3	1.3 / 40 = 3.25%
...		...	...	...
		Total	40	100%

Source: Author

After the analysis of all the projects, the column total score would register the sum of scores of each project. The division of this value by the total number of scores earned by all projects would give the general contribution of that initiative.

3.3 Prioritisation and selection of projects

The table developed through the project evaluation process represents the desire of execution in relation to project candidates. A list in descending order of contribution would be a natural prioritisation of the portfolio.

However, organisations have limits on the availability of financial resources, work capacity, machinery and equipment use hours, knowledge, among many other variables.

The selection, therefore, seeks to balance the prioritisation performed by managers with the limitations imposed on the organisation [Caballero et al., (2012), p.9; Knutson and Gump, (1996), p.4; Bullivant et al., (2008), p.5].

This procedure is described by PMI (2013a, p.71) in process 5.3 – optimise portfolio and in 6.2 – manage supply and need. In this step, one tool described is capacity analysis, which advises, "exceeding the available resources jeopardizes the portfolio's ability to attain its goals and benefits" [PMI, (2013a), p.74].

In this way, the public manager should prioritise those that contribute most to the organisation among the projects, according to the institution's limitations. One way to obtain the most beneficial result is the use of optimisation methods, such as the generalised reduced gradient algorithm (GRG2), which, according to Secchio (2005, p.95), has been shown to be the best method of successive linearisation.

Sacoman (2012, p.3) presents a guide to solve nonlinear programming using the generalised reduced gradient algorithm as shown below:

$$\text{maximise} \quad f(x) \tag{1}$$

$$\text{subject to:} \quad g(x) = 0 \tag{2}$$

$$a \le x \le b \tag{3}$$

Defined as: $x, a, b \in R^n$, $f : R^n \to R$, $g : R^n \to R^m eP = \{x \mid a \le x \le b\} \subset R^n$.

Step 1 Find an initial feasible solution x^0. Consider x^k a k[th] solution found by the algorithm.

Step 2 Calculate the Jacobian $\frac{\partial g}{\partial x^k}$ in point x^k and separate the variables in $x_B^k \in R^m$ and $x_N^k \in R^{m-1}$ to satisfy the hypotheses on non-degeneracy:

H1 $x_i \in P, \ \forall_i \in B$

H2 $\frac{\partial g}{\partial x^k}$ is not unique.

Step 3 Calculate the direction of the movement of non-basic variables, as follows:

1 calculate the langrage multipliers

$$u = -\frac{\partial f}{\partial x_B^k}.\left[\frac{\partial g}{\partial x_N^k}\right]^{-1}; \tag{4}$$

2 calculate the reduced gradient (RG)

$$\nabla_n f = \frac{\partial f}{\partial x_N^k} + u.\left[\frac{\partial g}{\partial x_N^k}\right]; \tag{5}$$

3 calculate the RG designed

$$\forall_{\in N, p_j} = \begin{cases} 0 & \text{if} \begin{cases} \nabla_j f < 0 e x_j^k = a_j \\ \nabla_j f < 0 e x_j^k = b_j \end{cases} \\ \nabla_j f & \text{otherwise} \end{cases} \tag{6}$$

if $p_N = 0$ stop; otherwise calculate $d_N = p_N$..

Step 4 Consider the optimality condition g'. $d = 0$ and calculate the direction of displacement of the basic variables. So $\frac{\partial g}{\partial x_B^k}.d_B + \frac{\partial g}{\partial x_N^k}.d_N = 0$ and, from the relationship, calculate d_B, where:

$$d_B = -\left[\frac{\partial g}{\partial x_B^k}\right]^{-1}.\left[\frac{\partial g}{\partial x_N^k}\right].d_N \tag{7}$$

Step 5 Improve the solution, as follows:

1 find the positive value θ that maximises $f(x + \theta, d)$

2 shift the variables, both non-basic and basic, according to directions calculated; calculate $\tilde{x}_N = x_N^k + \theta.d_N$ and $\tilde{x}_B = x_B^k + \theta.d_B$, finding $\tilde{x} = (\tilde{x}_B, \tilde{x}_N)$ that is not feasible. Then,

3 solve a system of m nonlinear equations to unknowns, for modification of the basic variables $g = (x_B, \tilde{x}_N) = 0$, by applying a method pseudo-Newton:

a calculate, iteratively, from $\tilde{x}_B$, the solution:

$$x_B^{t+1} = x_B^t - \left[\frac{\partial g}{\partial x_B^k}\right]^{-1}.g\left(x_B^t, \tilde{x}_N\right) \tag{8}$$

b consider $\tilde{x}_B$ the solution found and retrieved from $x^{k+1} = (\tilde{x}_B, \tilde{x}_N)$ can be such that:

- if $x^{k+1} \in P$, but $f(x^{k+1}) < f(x^{k+1})$, try to find a new point, reducing θ
- if $x^{k+1} \in P$, but $f(x^{k+1}) < f(x^k)$, try to find a better solution, increasing θ
- if $x^{k+1} \notin P$, change the base.

Step 6 Return to Step 2.

Following the steps indicated by Sacoman (2012, p.3), it is possible to calculate the optimal point of the solution; however, implementing these procedures requires in-depth mathematical knowledge by public managers. As these skills are not always present, the GRG2 algorithm can be easily manipulated through software, such as Excel (solver), in which the level of knowledge required by the user is minimal, allowing the use of the designed decision-making model.

When deciding to invest in a public project, the public manager only has the option of whether to invest in that initiative; therefore, it is a binary mathematical model. Caballero et al. (2012, p.6) present the objective function of a generic model for selecting and optimising a portfolio as follows:

$$Max\ Z = \sum_{i=1}^{n} c_i X_i \tag{9}$$

where Z is the total benefit of the portfolio, the function maximise is $i = 1, \ldots, n$; where n is the total number of projects considered in the portfolio;

$$X_i = \begin{cases} 1 & \text{if project is selected} \\ 0 & \text{if project is not selected;} \end{cases}$$

c_i is the benefit provided for each project.

Within this objective function, various restrictions may be applied, for example, budgetary resources, financial resources, people, equipment, knowledge, risk, among others. A function that represents this restriction can be:

$$\sum_{i=1}^{n} a_i X_i \leq b_j \tag{10}$$

where a_{ij} is the resource consumption j by the project i, being b_j the resource limit of j available for the execution of the entire portfolio of the organisation.

Caballero et al. (2012, p.6) remember there are cases in which there are dependency relationships between projects and programs or complementary projects, such as a sewer project being carried out concurrently with the paving of a road to avoid new asphalt cutouts. In this case, when a project j is selected and another project i must also be chosen, but the converse is not true, the restriction used is the following function:

$$X_j \leq X_i \text{ or } X_j - X_i \leq 0 \tag{11}$$

There are also cases in which the execution of a project prevents the execution of another, as in cases of competing projects. When this situation occurs, the following restriction must be added to the mathematical model:

$$X_j + X_i \leq 1 \tag{12}$$

Another possible constraint is the imposition of a project, since, regardless of the added benefit, the initiative is financed by external factors beyond the public manager's control. This project can be a counterpart to receive funding for another project, for example.

The public manager must analyse the portfolio and identify every constraint that applies to the projects under his responsibility to model the mathematical function used when calculating the optimal solution.

Table 8 Optimisation matrix

Project	*Rate*	*Financial*	*Man-hours*	*Job*	*Risk*	*Select?*
Project A	10.72%	6,177.00	78	14	0	
Project B	18.10%	24,345.00	433	13	1	
Project C	8.39%	15,902.00	322	19	3	
Project D	17.09%	5,350.00	385	20	10	
Project E	1.48%	24,547.00	407	11	9	
Project F	14.45%	10,080.00	430	18	10	
Project G	7.77%	14,464.00	242	2	10	
Project H	5.83%	17,478.00	170	4	2	
Project I	16.16%	22,777.00	436	6	4	

Source: Author

Table 8 exemplifies an array for portfolio optimisation, where nine projects (A–I) are available for public manager choice. In this array, the decision model of this organisation is based on the rate of contribution of each project, the financial investment, the volume of man-hours, the quantity of employment generated, and the relative risk of the initiative.

Considering the projects arranged in Table 8, it is possible to affirm the public manager's prioritisation, based only on the rate of contribution would be the implementation of the projects in the following order: B, D, I, F, A, C, G, H and E.

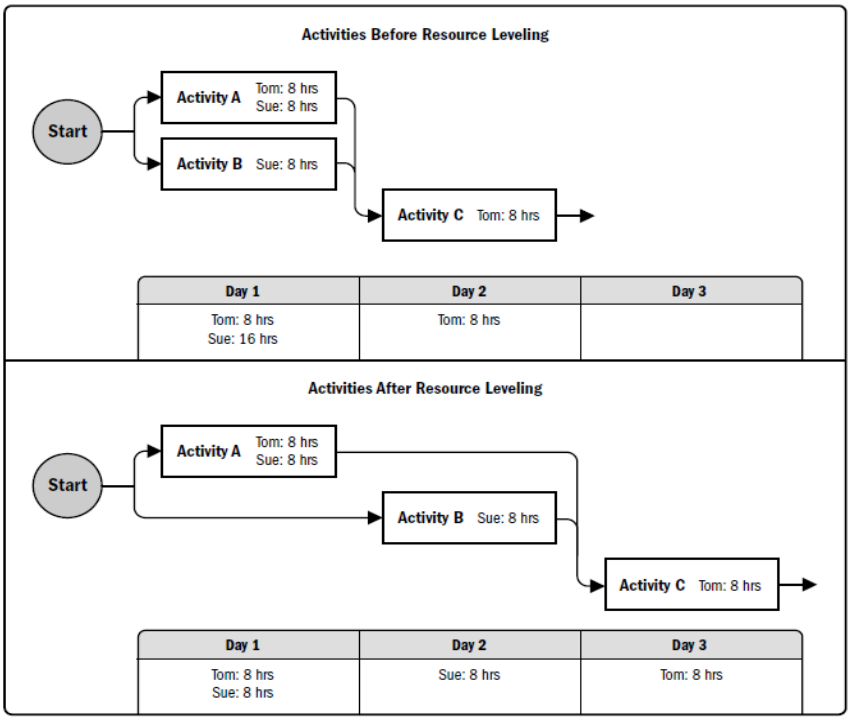
However, the organisations have limitations for every order; therefore, to solve the problem described in Table 8, it is necessary to consider the constraints imposed on the model. If the restrictions were the existence of only \$60,000.00 to invest and 2,000 man-hours, the selected projects would be only D, I, F, and G.

The selection of these projects represents the best possible return for the organisation, which is on the order of 66.19% using \$58,848.00 and 1,571 hours of work.

The public manager could use other variables to maximise, minimise, or achieve depending on the scenario. At a time of economic crisis, for example, the manager might opt for a less risky portfolio or one capable of generating the largest number of jobs to run a counter-cyclical policy.

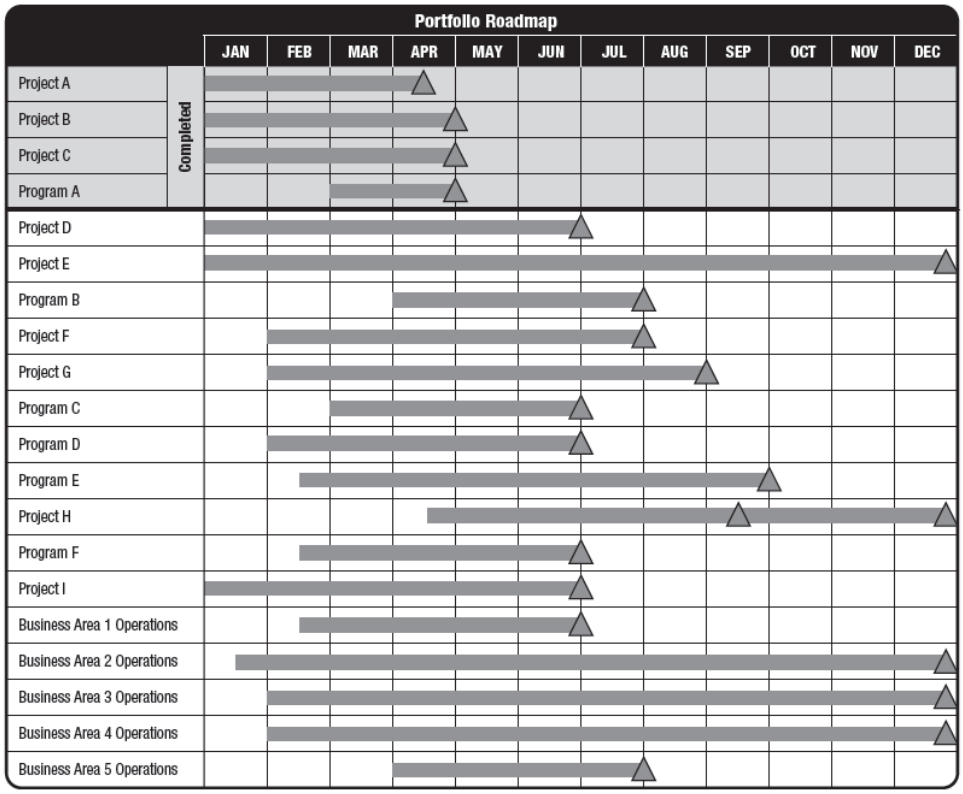
Whatever the criteria adopted by the public manager, at the end of this step, the organisation will have an optimal list of projects that must be selected and implemented.

Figure 6 Resource levelling



Source: PMI (2013b, p.179)

Figure 7 Portfolio roadmap



Source: PMI (2013a, p.52)

3.4 Resource levelling

When the list of selected projects is developed, the public manager deploys them in time to leverage the use of resources. During selection, financial resources, working hours, machinery availability, among other constraints, are viewed as absolute, without considering the distribution of these constraints during the horizon of time used in the selection process.

The result of this levelling process is the development or updating of a high-level schedule, as described in process 4.3 – define portfolio roadmap. Figure 7 illustrates a portfolio roadmap.

Financial resources, for example, are not available in its entirety for execution of all projects at once. With public administration, these resources are the inputs made by the payment of taxes, which occur gradually.

Human resources are subject to holidays, sick leave, and limits of daily work; therefore, projects that use the same human resources cannot run concurrently without risking overloading people.

Machinery and equipment have limits and, if allocated to a given project, it may not be possible to use them in another project during the same period.

For these reasons, it is necessary to level the resources through a technique described by PMI (2013b, p.179) in process 6.6 – develop schedule and in process 6.2 – manage supply and demand [PMI, (2013a), p.95]. Figure 6 presents a case of resource levelling in a project:

When developing or updating the portfolio roadmap, it is incumbent on the manager to develop the public agenda with the many activities necessary for the timely and efficient implementation of the selected projects, such as the search for financing, political support, approvals, among others.

4 Conclusions

In a survey conducted by the Brazilian Institute of Tax Planning (IBPT) (2013, p.2), Brazil, among the 30 countries with the highest tax burden, "remains which provides the worst return of amounts collected for the well-being of society".

The studies presented by Gemünden et al. (2013), the pulse of the profession: portfolio management report (PMI, 2014), and pulse of the profession: the high cost of low performance (PMI, 2016) demonstrates the need to have good processes defined for the selection of projects to improve Brazilian public spending.

The tools and techniques in this article are widely used in private organisations worldwide and allow the choice of those projects that most contribute to social welfare, directly fighting the inefficiency of the state shown by the IBPT (2013) report.

Public and private organisations that want to use such tools and techniques must adapt them to the level of organisational maturity, incorporating new processes, changing internal procedures, among others, to allow the introduction of the method to the portfolio management processes existing in the organisation.

It is believed that introducing the techniques and tools in this article within public organisations will allow for improvements in public spending quality through a process of rational decision-making compatible with the public interest, less subject to political interference, and able to generate the best possible return on the resources allocated by the citizens for the sake of building a country in reference to the quality of social welfare.

This article started intending to answer the following questions: What are the best practices in portfolio management? How can we apply portfolio management in public organisations? These questions were answered during the article, although more research is necessary to measure the benefits of portfolio management practices on public organisations, with the agenda for new research to be explored.

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