Politecnico di Milano
School of Industrial and Information Engineering
Master of Science in Management Engineering

POLITECNICO
MILANO 1863

Business Performance Analytics applications and benefits: a theoretical framework and some exploratory case studies

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Academic Year 2017/2018

Acknowledgements

I would like first to express my appreciation to Professor Paolo Maccarrone for his support and useful critiques in key moments of the research.

I would also like to thank all the professionals that made this research possible by dedicating their time for the interviews.

Finally, I recognize that this research, and all my path at Politecnico di Milano, would have never been possible without the love of my family and Alice, or without the friendship and support of my friends in Vimercate, Politecnico di Milano and Tsinghua University.

Thank you all.

Giacomo

ABSTRACT

The study investigates Business Analytics and Big Data applications in the domain of Finance function and controller activities, addressing the topic as Business Performance Analytics (BPA) accordingly to the nomenclature provided by Silvi & Visani (2016).

BPA is recognized to have an high potential impact on companies' performances and as source of sustainable competitive advantage. Nevertheless, few researches address directly the topic, often focusing on specific techniques and application areas. This Master Thesis effort aims therefore at contributing to bridge this gap, understanding from a managerial perspective how companies in the market implement Business Performance Analytics systems, analyzing its key components; which improvements it brings to controller activities; overall company benefits pursued. Finally, the Master Thesis contributes to solve a controversy about CFO role evolution as a consequence to BPA: will it become CEO's strategic advisor and evolve as analytics leader, or reduce its strategic relevance?

To achieve these goals, a qualitative rather than quantitative approach has been selected, primarily because of the lack of adequate support from existing literature. Firstly, it is developed a theoretical framework; secondly, the theoretical framework is endorsed by interviewing practitioners and field experts; thirdly, it is further supported from eight exploratory case studies, proving it can adequately describe company applications.

Keywords: Business Performance Analytics; Big Data; Business Analytics; Finance

ABSTRACT [ITALIAN]

Lo studio indaga le applicazioni di Business Analytics e Big Data nell'ambito della funzione di Finanza e nelle attività dei controller, affrontando l'argomento come Business Performance Analytics (BPA) in base alla nomenclatura fornita da Silvi & Visani (2016).

Si ritiene che BPA abbia potenzialmente un elevato impatto sulle prestazioni aziendali, e che possa agire da fonte di vantaggio competitivo sostenibile nel lungo periodo. Tuttavia, poche ricerche affrontano direttamente l'argomento, spesso concentrandosi su specifiche tecniche o aree di applicazione. Questa tesi mira quindi a contribuire a colmare questa lacuna, comprendendo dal punto di vista manageriale come le aziende nel mercato implementino i sistemi di analisi delle performance aziendali, analizzando le sue componenti chiave; quali miglioramenti apportino alle attività dei controller e in che modo esse vengano influenzate; i benefici globali perseguiti. Infine, la tesi contribuisce a risolvere una controversia sull'evoluzione del ruolo del CFO come conseguenza sei sistemi di BPA: diventerà "Strategic advisor" del CEO e si evolverà come "analytics leader", o vedrà ridursi la sua rilevanza strategica?

Per raggiungere questi obiettivi, è stato selezionato un approccio qualitativo, principalmente a causa della mancanza di un adeguato sostegno dalla letteratura esistente. In primo luogo, è sviluppato un framework teorico; in secondo luogo, esso è validato intervistando professionisti ed esperti sul campo; in terzo luogo, è ulteriormente supportato da otto casi studio esplorativi, dimostrando che può descrivere adeguatamente le applicazioni del settore e rispondere alle domande di ricerca.

Parole chiave: Business Performance Analytics; Big Data; Business Analytics; Finanza

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1. EXECUTIVE SUMMARY

1.1 Literature review

Big Data and Business Analytics are a complex and recent phenomenon that is deeply influencing how companies work, up to the point to be considered a "Management revolution" (McAfee & Brynjolfsson, 2012). Their impact in a firm is incredibly wide, and involves not only technology, but also competencies, organization and culture (Burton et al., 2014; T. H. . Davenport & Patil, 2012; T. H. Davenport & Bean, 2018). In particular, Big Data and Business Analytics are considered the missing link between complex Performance Measurement and Management Systems (PMMS) and their implementation (Schläfke et al., 2012) and in general a solution to the stagnant status of research in the accounting field (Merchant, 2012). The merging of these disciplines is called Business Performance Analytics (BPA). It consist of performance management models that, through 1) PMMS, 2) IT infrastructure, 3) Big Data and 4) Business Analytics improve business dynamics understanding, business strategies development and performance measurement and management (Silvi & Visani, 2016). Four key components can therefore be identified.

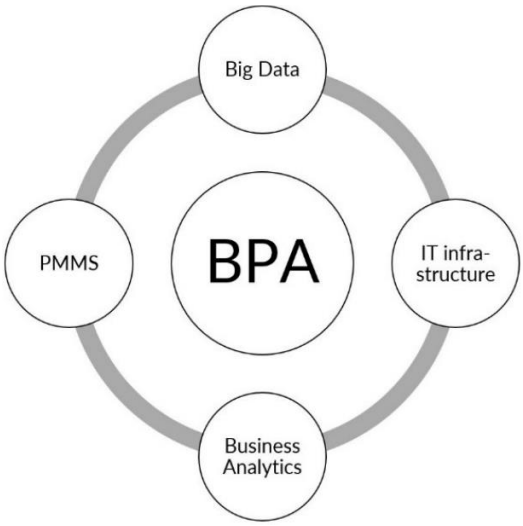


Figure 1-1, BPA key components, adapted from Tavola 7 in Silvi & Visani, 2016

A PMMS is a multi-dimensional set of metrics used to quantify both efficiency and effectiveness of actions, planning and manage the future of a business (Bourne et al., 2003; Neely et al., 1995), and it is enabled by IT infrastructure (Ferreira & Otley, 2009). IT infrastructure is rapidly evolving both in terms of enabling infrastructures (from data

warehouse to data lake) and software (from SQL to NoSQL and NewSQL systems) to support Big Data and Business Analytics (Osservatorio Big Data Analytics & Business Intelligence, 2017). For definition, in fact, Big Data cannot be managed from typical database software tools (Manyika et al., 2011) because of its characteristics of high Volume, Variety and Velocity (McAfee & Brynjolfsson, 2012). Business Analytics, such as machine learning and data mining (Appelbaum et al., 2017), are employed to analyze them, and are classified according to their orientation, that can be descriptive (analyzing historical data), predictive (analyzing data future evolution) and prescriptive (given a scenario, what is the best action to take?) (Holsapple et al., 2014). Four key components contribution to BPA system can be therefore synthetized as follows:

- *PMMS*, which sets BPA system goals;
- *IT infrastructure*, which enables BPA system;
- *Big Data*, which act as BPA "fuel";
- *Business Analytics*, which manipulate *Big Data* through *IT infrastructure* tools to achieve goals set by PMMS.

Despite the relevance recognized to BPA, research is still in its infancy, and does not meet expectations (Ask et al., 2016). In particular, as Raffoni et al. (2017) notices, studies focus on theoretical implementation frameworks, lacking empirical validation. Schläfke et al. (2012) and Silvi et al. (2010) are studies presenting this weakness. Recently, journals published researches bridging this gap in specific areas of Performance Measurement and Management, implementing, for examples, Business Analytics in tools such as the Balance Scorecard (BSC) adopting both a practical (Nielsen, 2017) and theoretical (Appelbaum et al., 2017) approach, or methodologies such as the Total Cost of Ownership (TCO) (Visani, 2016). It has been explained that BPA is a complex multidisciplinary system, impacting the whole company. Silvi & Visani (2016) analyzes its key components, while Raffoni et al. (2017) considers challenges that need to be faced in the implementation process building a framework later validated also from Visani (2017). *Table 1-1* resumes this literature analysis, highlighting an existing gap in existing literature.

		Approach	
		Theoretical	Practical
Scope	Specific tool	Appelbaum (2017)	Visani et al. (2016); Nielsen (2017)
	BPA as a whole	Silvi & Visani (2016); Warren et al., 2015 Silvi et al. (2010); Schläfke et al. (2012)	Raffoni et al. (2017); Visani (2017);

Table 1-1, Core papers classification highlighting a gap in literature

It summarizes consideration presented above, showing that exist two studies adopting a practical approach and analyzing the BPA system as a whole. However, Raffoni et al. (2017) and Visani (2017) do not consider impacts controllers' daily activities, but macro-steps of BPA implementation.

1.2 Objectives

The thesis, therefore, aims at contributing to bridge this gap, providing a comprehensive picture of BPA, its applications and its influence on business dynamics from a practical point of view, providing in this way an overview about companies' strategic decision-making concerning the configuration and adoption of these tools. The following research questions have therefore been formulated:

RQ 1

While BPA key components, showed in *Figure 1-1,* are well analyzed by Silvi & Visani (2016) from a theoretical point of view, their diffusion and configurations in the market are not clear. This research question aims therefore at clarifying this point.

<<What is the degree of diffusion of BPA systems among companies, in terms of key components (PMMS, IT infrastructure, Business Analytics, Big Data)?>>

RQ 2

Existing literature put relevant efforts to provide BPA system implementation best practices (Raffoni et al., 2017; Visani, 2017). However, it has not been investigated how,

in a fully or partially implemented system, each od the several improvements it generates influence business dynamics and particularly controllers' activities.

<< How do BPA improvement areas impact controllers' activities?>>

RQ 3

Existing literature suggests what benefits can Big Data and Business Analytics bring to companies (McAfee & Brynjolfsson, 2012; Tien, 2013), but it does not focus on BPA. The third research question aims at evaluating these benefits, attempting to confirm or not results from previous more general studies.

<<Which advantages are pursued from companies implementing a BPA system?>>

1.3 Methodology

It has been selected a qualitative approach. The reason lies in the infancy status of BPA research, so that many issues have not been tackled directly from existing literature. In fact, while Big Data and Business Analytics have been deeply analyzed, their application in BPA domain is still scarce. Therefore, a structured survey may be misunderstood from interviewees, and important aspects neglected. The methodology therefore is composed by the following three main steps:

1) Development of an original theoretical BPA framework, both organizing existing literature directly addressing BPA (e.g. Silvi & Visani, 2016) and adapting general results about Big Data, Business Analytics and management control tools impact (e.g. McAfee & Brynjolfsson, 2012);

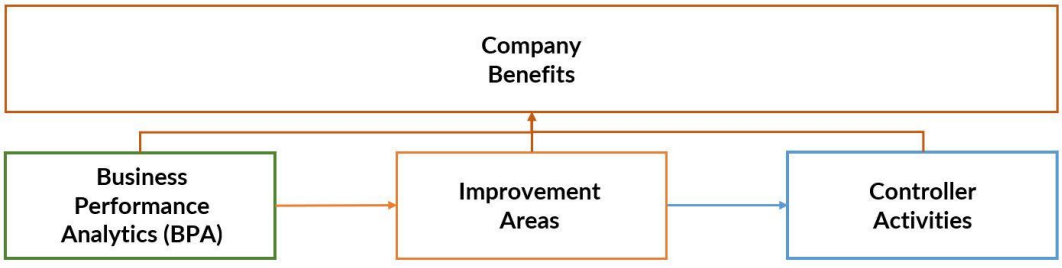


Figure 1-2, BPA framework primary blocks

2) Since existing literature, as already mentioned, does not describe satisfyingly topics addressed by BPA framework, it has been necessary to validate and enrich it through preliminary interviews with field experts and practitioners;

3) Finally, eight companies have been selected to develop an exploratory case study research, which proved framework effectiveness describing BPA systems in real scenarios.

Case studies interviews followed a semi-structured approach, allowing differences among companies to emerge. In fact, they differ in terms of size, industry and culture, variables believed to have an influence on BPA system configuration. Each case study followed the same macro-steps:

1) Brief introduction of Master Thesis subject via email/phone;
2) BPA framework presentation and explanation face to face;
3) Ask interviewee to briefly introduce the company he is working for, together with business and market peculiarities:
4) Ask the interviewee to comment BPA applications currently present in the company and future projects, providing feedbacks about framework clarity and completeness;

1.4 BPA framework

The resulting framework is composed by 4 primary blocks and 20 secondary blocks, and it is modelled so that investigating their content and relationships among them, research questions are answered. In fact, it aims to explain how a specific BPA system configuration (*RQ 1*) can bring which improvements to a list controllers' activities (*RQ 2*). Finally, which benefits do BPA and its improvement areas to controller activities bring to the company as a whole (*RQ3*)? The output is descriptive and robust thanks to a detailed and comprehensive analysis and re-organization of existing literature, and to the validation and enrichment obtained thanks to the afore mentioned preliminary interviews. *BPA* block is based on Silvi & Visani, 2016. Secondary blocks have been adequately detailed in dedicated chapters, giving special attention to Big Data and Business Analytics. They are the innovative elements in the block, and therefore the most challenging to deal with for companies. *Improvement Areas* identification is based on several core papers (Accenture, 2018; Barton & Court, 2012; Chang et al., 2014; G Cokins, 2013b; Gary Cokins, 2014; Gandomi & Haider, 2015; Manyika et al., 2011; Network Digital 360, 2017; Plaschke et al., 2018), and then rectified by preliminary interviews; *Controller Activities* have been classified following a report by Accenture (Accenture, 2018), investigating

technologies related to BPA adoption in Finance function; *Company Benefits* block has been developed with the same approach as *Improvement Areas* one, therefore grouping different studies and then including suggestions from interviewees.

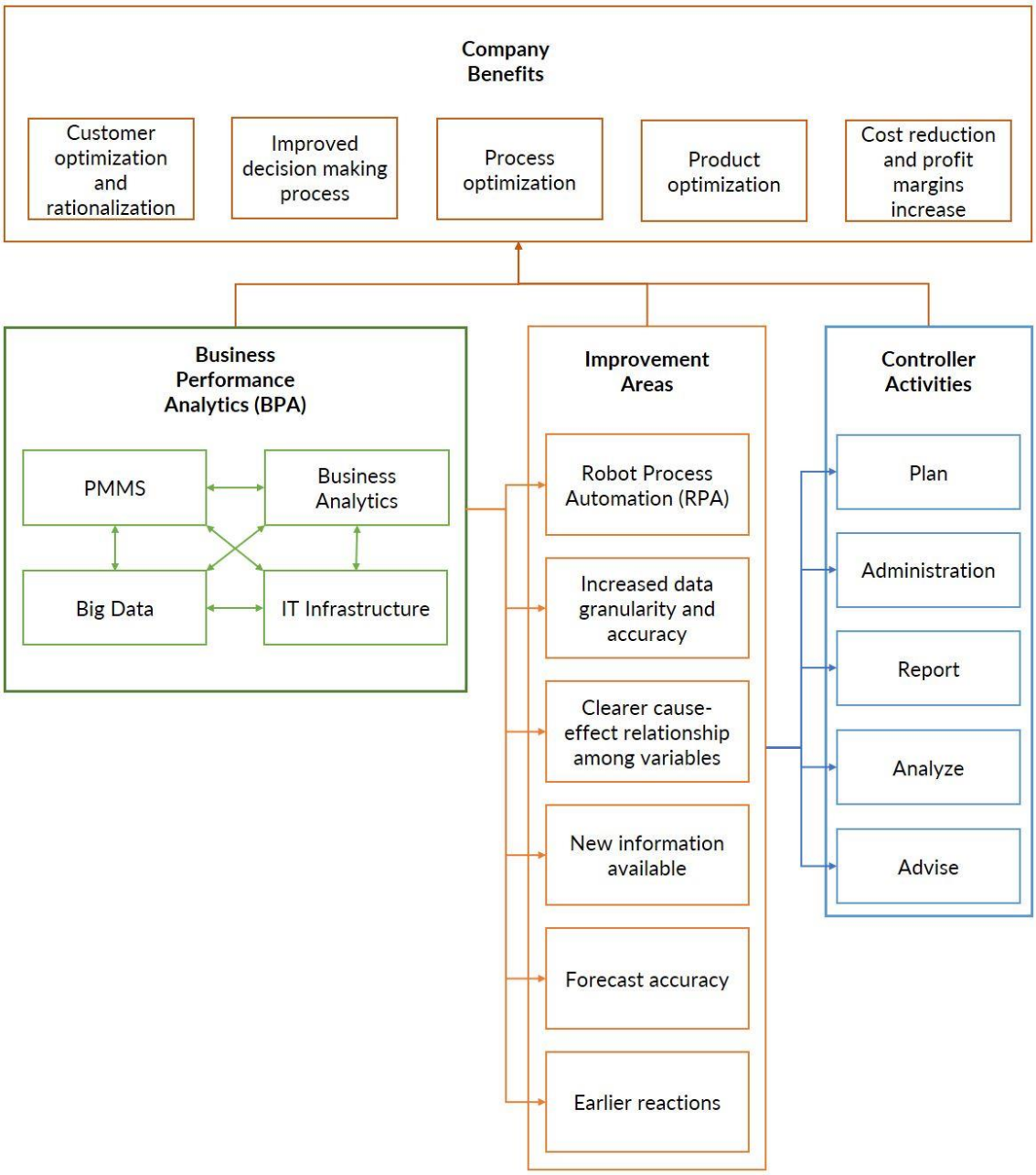


Figure 1-3, BPA framework

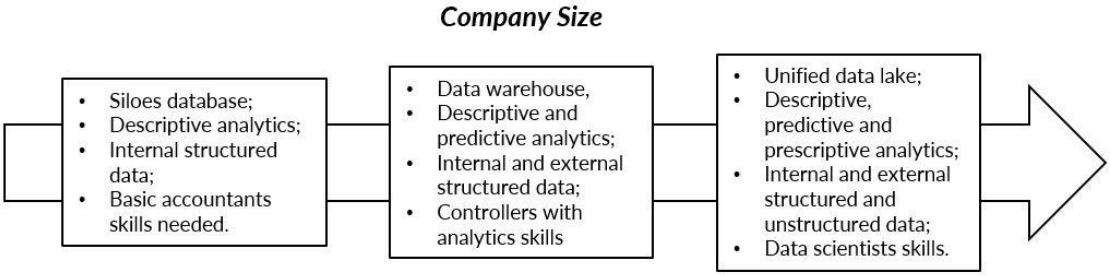
1.5 Results

A cross-case study analysis of each block allowed to enrich the framework, understanding their content and existing relationships among them, leading therefore to answer research questions. Here, final results are presented.

RQ 1

<< What is the degree of diffusion of BPA systems among companies, in terms of key components (PMMS, IT infrastructure, Business Analytics, Big Data)?>>

BPA diffusion and macro-configuration in terms of key components has been found to depend primarily on *Company Size*.



Graph 1-1, BPA diffusion and configuration depends on Company Size

Case studies allowed to analyze different firm sizes, ranging from Small-Medium Enterprises (SMEs) to Fortune 500 companies. Large firms have both more need of BPA systems, that enable to analyze and find correlations between different business lines and markets, and capabilities to invest in technologies and competencies. Currently, being BPA systems still in the infancy of their evolution, other drivers are still not definite enough. This has been suggested from several interviews, for example:

<<When we kicked off our analytics project for performance management, we started looking for benchmarks, but didn't find any. This is something completely new not only for us, but for the market>> Energy S.p.A. AFC Digital Hub - Chapter Leader Data Competence Center & Advanced Analytics.

RQ 2

<<How do BPA improvement areas impact controllers' activities?>>

Despite there is not statistical evidence and therefore results cannot be generalized, *Improvement Areas* relevance, and therefore their impact on controllers' activities, have been measured and classified.

	Tools S.p.A.	Fintech S.p.A.	Glue S.p.A.	Liquid S.p.A.	Energy S.p.A.	Nice House S.p.A.	Water S.p.A.	Pharma S.p.A.	Relevant in (%) of case studies	Most important in (%) of case studies
Robot Process Automation (RPA)				**X**					62,50%	12,50%
Increased data granularity and accuracy		**X**			**X**				**87,50%**	25%
Clearer cause-effect relationship among variables	**X**		**X**		**X**	**X**	**X**		**87,50%**	**62,50%**
New Information available									62,50%	0%
Forecast accuracy							**X**	**X**	75%	25%
Earlier reactions									37,50%	0%

= *Relevant in the case study* **X** = *Most important*

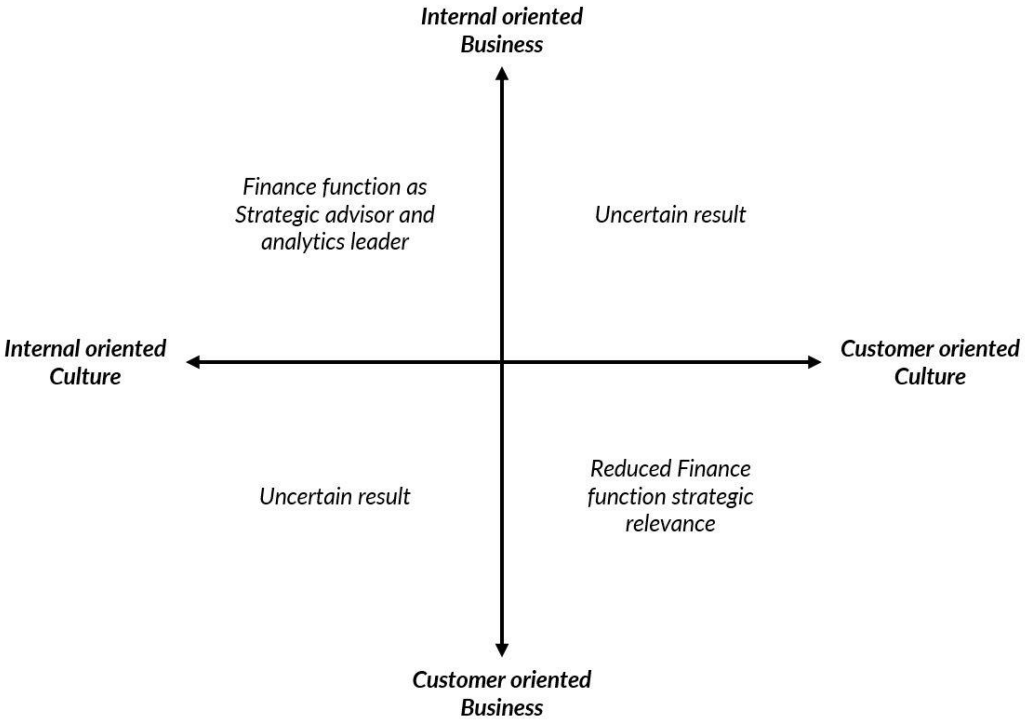
Table 1-2, Improvement Areas block results summary

From *Table 1*-2, it is possible to notice that *Increased data granularity and accuracy* and *Clearer cause-effect relationships among variables* are considered the improvements impacting *Controller Activity* the most, but how? Two main relationships have been identified, depending on activity category:

- Operational → *Administration*, (*Report*);
- Strategic → *Plan*, *Analyze*, *Advise*, (*Report*).

Report activity can be both Operational and Strategic, depending on company choices. While advanced robots, through *Robot Process Automation (RPA)*, are now executing most of the repetitive and not value adding Operational activities, BPA is enriching and increasing strategic ones potential, thanks to *Increased data granularity and accuracy*, *Clearer cause-effect relationship among variables*, *New information available*, *Forecast accuracy* and *Earlier reactions*. Controllers can now take more fact-based decisions adopting a data-driven approach. Entering Lebanon market, which brand and which kind of stores should we adopt? This is an example of strategic decision now supported from BPA in a furnishing retail company included in case studies. Detailed impacts examples have been firstly presented in the Case Studies chapter, and then summarized in the Discussion and Results one.

These first results about BPA impact on controllers' activities make possible to formulate some hypotheses about Finance function role evolution, topic long debated in literature: will it become CEO's "Strategic advisor" (Gary Cokins, 2014) and "ramp up as analytics leader" (T. H. Davenport & Tay, 2016), empowered by BPA, or its strategic relevance will reduce because of automation (Frey & Osborne, 2013)? Two main evolution drivers have been identified during exploratory case studies: Business and Culture. Characteristics of company's business, for example market and customers, together with its culture and strategy will determine the impact of BPA on Finance function role. While a business strongly influenced by consumers' needs and whose culture is oriented to customer service and product differentiation will most likely decrease Finance function strategic relevance, another business operating in a commodity market and culturally oriented to its internal processes and cost reduction will tend to move in the opposite direction.



Graph 1-2, Finance function role evolution

RQ 3

<<Which advantages are pursued from companies implementing a BPA system?>>

Table 1-3 provides an overview of results, highlighting most mentioned *Company Benefits* in exploratory case studies.

	Tools S.p.A.	Fintech S.p.A.	Glue S.p.A.	Liquid S.p.A.	Energy S.p.A.	Nice House S.p.A.	Water S.p.A.	Pharma S.p.A.	Relevant in (%) of case studies	Most important in (%) of case studies
Customer optimization and rationalization									12,50%	0%
Improved decision making process			**X**		**X**	**X**			**100%**	37,50%
Process optimization	**X**	**X**		**X**			**X**		87,50%	**50%**
Product optimization	**X**								25%	12,50%
Cost reduction and profit margins increase									**100%**	0%

= *Relevant in the case study* **X** = *Most important*

Table 1-3, Company Benefits block results summary

Other than *Cost reduction and profit margins increase*, that is, not surprisingly, a key goal for all companies studied, *Improved decision-making process* and *Process optimization* have been found to be the most pursued *Company Benefits*. In fact, the former is achievable thanks to the data driven approach guaranteed by BPA, while the latter is achieved automating controllers, repetitive activities, and making easier to identify inefficiencies in other processes. Other *Company Benefits* are matched in case studies, but rarely and indirectly. *Customer optimization and rationalization* and *Product optimization*, in fact, are often not directly addressed by BPA projects, but instead by other data analytics implementations in Marketing function.

It is important to highlight once again that, because of the qualitative nature of this study, results cannot be generalized. Nevertheless, they are satisfying: research questions have been answered and BPA framework is well suited to describe applications present in the industry. It can therefore serve as starting point for further research, that can investigate more in detail a specific block, or a specific relationship among blocks.

2. INTRODUCTION

Big Data and Business Analytics research is acknowledged to be of high and increasing relevance since 2011 (Fosso Wamba et al., 2015; Frizzo-Barker et al, 2016)**.** In 2012, this trend was firstly recognized by the Harvard Business Review. It published a special issue hinged on these topics, which articles would have been quoted many times in the forthcoming years. For instance, T. H. . Davenport & Patil (2012) focuses on new roles that will be necessary in companies, while McAfee & Brynjolfsson (2012) emphasizes not only advantages, but also challenges and the barriers that could compromise the development of this new phenomenon. From that moment, research never slowed down, covering different aspects and applications of the "Management revolution" (McAfee & Brynjolfsson, 2012).

But what is it Big Data? Information technologies experimented a rapid development, allowing the collection of a greater amount of data and information from, for example, e-commerce, smart city surveillance camera, GPS systems and social networks. Some data can better describe this phenomenon: all over the world, the per-capita capacity to store information has roughly doubled every 40 months since the 1980s as of 2012; every day 2.5 Exabyte (2.5×10^{18} bytes) of data were created; as of 2014, every day 2.3 Zettabyte (2.3×10^{21} bytes) of data were created (Sh. Hajirahimova & S. Aliyeva, 2017). Data generation acceleration is caused also from Internet of Things technologies implemented in companies. RFID-enabled item-level tagging is one of them: it has been estimated that the number of tags rose from 1.3 billion in 2005 to 30 billion in 2013, and therefore the amount of data generated (DeRoos, 2013).

Not only volume however, but also variety and velocity are characteristics that had a steep increase in the last decades, making them not manageable anymore from traditional technologies. A new paradigm is therefore necessary, and this paradigm is Big Data (Baharu & Sharma, 2016). Volume, variety and velocity constitute the three basic characteristics of data that can be classified as Big Data (McAfee & Brynjolfsson, 2012; Russom, 2011).

Researchers agree that Big Data can be decisive creating a competitive advantage for companies (Fosso Wamba et al., 2015). However, this is possible only developing a precise data strategy (DalleMule & Davenport, 2017; T. H. Davenport & Bean, 2018;

Stefan Biesdorf, 2013). Companies, therefore, do not have only to invest on, but also follow closely Big Data projects, tailoring a detailed strategy that includes every area of the business.

Among these areas, there is one that is recognized to be of great relevance, but whose research is still not as developed as it would deserve: Performance Measurement and Management (Ask et al., 2016; Jayakrishnan et al., 2018; Rikhardsson & Yigitbasioglu, 2018). The importance of this topic has been recognized years ago; in fact, already in 2012 (Schläfke et al., 2012) appeared the first literature-base analyses directly addressing it. Anyway, in the following years, few researches have been conducted, and with only little focus on practical case studies. This led other academics trying to raise the interest about it with a dedicated "Call for action" (Ask et al., 2016). In the recent past, more exploratory case studies are emerging, validating implementation models and frameworks (Raffoni et al., 2017; Vallurupalli & Bose, 2018; Visani, 2017).

But why Performance Measurement and Management, and in general Management Control and controllers' activities, is considered to be so affected from Big Data and Business Analytics revolution? It has been pointed out that they can bring data and rigor in areas traditionally more dominated by intuition (McAfee & Brynjolfsson, 2012). At the same time, many researchers argues that there is a gap between theory and practice in accounting research (Merchant, 2012). Nielsen, 2017 suggests exploiting Business Analytics to start developing theories in this field that can finally be more fact-based, and therefore more easily implementable in real scenarios. Analytical Performance Management (APM) is an approach to business management enabling Business Performance Analytics (BPA), that in turn consists of models supporting performance monitoring and management, that help understanding business dynamics and strategies through consisting in exploit analytics. These models can support and enhance Performance Measurement and Management (PMM), for instance being able to quantify relationships among financial and non-financial performance indicators (T. H. Davenport, 2008), making therefore more powerful dashboards system such as the popular Balance Scorecard (BSC) (R. S. Kaplan & Norton, 1992). Therefore, Big Data and Business Analytics do not only have general ROI benefits for companies (Accenture, 2013), but also specific ones related to the field of accounting and control.

Fully embrace an analytics culture is necessary to achieve effective implementation of Big Data and Business Analytics systems across the company, but it involves a relevant mindset shift (DalleMule & Davenport, 2017; T. Davenport, 2017; T. H. Davenport & Bean, 2018). It implies therefore several challenges of different nature to be overcome. Different studies focused on identifying them, in order to support companies during the innovation process. They have been classified, for instance, as: managing data quality, using analytics for improved decision making, creating a Big Data and analytics strategy, availability of data, and building data skills in the organization (Vidgen et al., 2017); leadership, talent management, technology, decision making, company culture (McAfee & Brynjolfsson, 2012); related to Big Data characteristics, that are volume, variety and velocity (Ask et al., 2016).

From the information presented, it is possible to understand that Business Performance Analytics is an hot topic among researchers and practitioners, that can certainly bring significant benefits to companies. Controllers' activities and in particular Performance Measurement and Management is one of the areas where advantages are more evident; nevertheless, still minor focus has been put on it, and in particular few practical cases have been investigated. The purpose of this research is therefore to contribute closing this gap, analyzing how different companies have implemented Business Analytics in Finance function, drawing an overall picture, and then drafting general conclusions about best practices. A theoretical framework will be firstly designed through existing literature and practitioners suggestions; then, it will be detailed and enriched through several exploratory case studies.

2.1 Structure of the thesis

After a brief Introduction, necessary to let the reader understand general and specific characteristics of the topic addressed by this Master Thesis effort, the third chapter reviews existing literature, addressing one by one the key components of a BPA system as identified by Silvi & Visani, 2016. They are Performance Measurement and Management System, IT infrastructure and technology, Business Analytics and Big Data. Then, in the same chapter, advantages and challenges of this paradigm are presented; finally, the Literature Review chapter ends summarizing findings, explicating research questions and expectations. The third chapter describes the Methodology followed to

answer research questions, divided in two macro-phases: the development of a theoretical framework and then exploratory case studies to understand in detail how its blocks and links work in a real scenario. Between them, it has been conducted a preliminary framework validation phase, interviewing academics and practitioners about its meaningfulness and clearness.

Then, it is firstly developed the BPA framework and described its components. Secondly, case studies are presented one by one. Concluded this phase, it is possible to discuss results and how case studies enrich the first version of the framework. Finally, conclusions are drafted, and limitations and suggestions for future research are presented.

3. LITERATURE REVIEW

In the Literature Review chapter is firstly presented the methodology followed to select relevant research papers to be included in the research. Then each topic identified as pertinent to the research scope is analyzed. Finally, findings are summarized, as a preliminary step to research questions formulation in chapter 4.

3.1 Methodology

The Literature Review has been developed following a structured process. The main databases used have been Scopus and Web of Science (WOS). Scopus, on its own website, claims to be "*the world's largest abstract and citation database of peer-reviewed literature, including scientific journals, books and conference proceedings*". It gives four types of quality measures for each title, that are h-Index, CiteScore, SCImago Journal Rank and Source Normalized Impact per Paper. On the other hand, Web of Science advertises that "you can access an unrivalled breadth of world-class research literature linked to a rigorously selected core of journals and uniquely discover new information through meticulously captured metadata and citation connections". They are both considered trustable, comprehensive and provide useful tools for citation analysis; however, they complement each other, as neither resource is all inclusive (Burnham, 2006).

Keywords used have been first strictly focused on the topic, to be able to have an overview. Therefore, "Big Data" AND "Performance measurement"; "Big Data" AND "Performance Management"; "Business Analytics" AND "Performance measurement"; "Big Data" AND "Performance management". After this first step, it was clear the nomenclature commonly used in the specific research field. A second round of research included therefore the keywords "Analytical Performance Management", "Business Performance Analytics" and "Performance Management Analytics". At this point, also paradigm key components were known, and it was therefore possible to deepen the research in each of them: IT technology and systems, Performance Measurement and Management, Business Analytics and Big Data (Silvi & Visani, 2016). Priority was given to documents presenting strict relationship with the core of the research. However, also others only indirectly related were analyzed to grasp possible different perspectives.

Articles and reports drafted from renowned consulting companies were included in the literature review, both searching on their website and following citations present in other papers. Another magazine from which many articles have been read and analyzed is the Harvard Business Review (HBR), where T.H. Davenport, one of the most relevant authorities in the field of Big Data and Business Analytics, published many of his articles. There has also been the possibility to contact directly one of the main contributors to the APM field, Riccardo Silvi, who suggested key papers to be analyzed to fully comprehend all the issues regarding the subject. Secondary papers were selected to select the appropriate research approach, composing therefore a database of 114 documents.

3.2 Introduction on Business Performance Analytics (BPA)

This chapter summarizes findings in previous research regarding the application of Big Data Analytics (BDA) in Performance Measurement and Management Systems (PMMSs), and related relevant areas. The merging of these two areas is named Business Performance Analytics (BPA). It consist of models supporting performance monitoring and management, that help understanding business dynamics and strategies through (Silvi & Visani, 2016). It has four key components:

- Information Systems (IS) and Information Technology (IT);
- Big Data;
- Analytical tools and methods, named Business Analytics;
- PMMS.

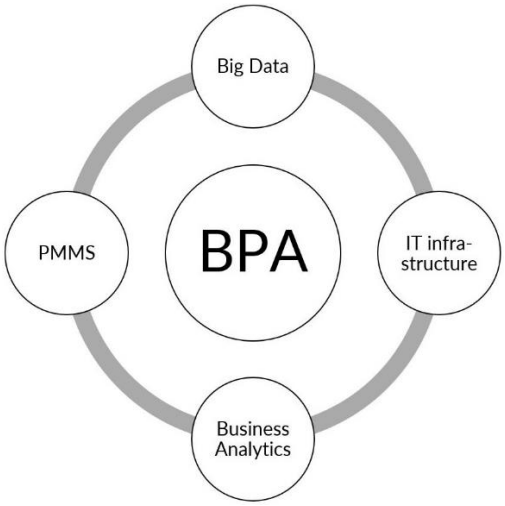


Figure 3-1, BPA key components, adapted from Tavola 7 in Silvi & Visani, 2016

The approach to business management that exploits BPA is called Analytical Performance Management (APM) (Silvi & Visani, 2016).

3.3 First component: Performance Measurement and Management Systems (PMMS)

It is relevant to the purpose of the research to provide an insight on what is a background of the core topic. In fact, BPA is an improvement to controllers' activities and an enhancement of management accounting. In particular, it is the missing link between complex PMMS and their effective implementation (Silvi et al., 2010).

PMMS is enabled by Information Systems (IS) and Technology (IT) (Ferreira & Otley, 2009; Otley, 1999). IS and IT are used to organize accounting information and other control information (Ferreira & Otley, 2009); an example are ERP systems that, even though have not been developed with this specific purpose and were initially considered a fad, are interdependent with PMMS and management control systems in general (Chapman, 2005). IS and IT can make organizations more complex, and allow their description through accounting representations; this relationship, however, is complex and still not clear in all its aspects (Dechow et al., 2006). What has been long noted is that accounting cannot be practiced without IT (Dechow et al., 2006).

A Performance Measurement and Management System can be defined as a multi-dimensional set of metrics used to quantify both efficiency and effectiveness of actions, planning and manage the future of a business (Bourne et al., 2003; Neely et al., 1995). PMMS history can be tracked back to the 40s and 50s. At that time Japanese and Western companies had completely different strategies and production systems, focused respectively on efficiency and innovation, and therefore needed different PMMS (Nudurupati et al., 2011). After criticism was moved towards U.S. managers because of their short-term view (Hayes & Abernathy, 1980), in the 80s the potential of Japanese techniques was recognized, and more complex PMMS including more dimensions (such as time, cost, quality, flexibility) were developed (Nudurupati et al., 2011). Later in the 80s and in the 90s also non-financial measures started to be considered fundamental for comprehensiveness reasons, and new frameworks were developed to include them, such as the BSC (R. S. Kaplan & Norton, 1992). PMMS is a topic still under fast development,

that must adapt to trends such as multi-cultural supply chains and networks, servitization and digitalization (Nudurupati et al., 2011) and of course to Big Data (Silvi et al., 2010).

The lifecycle of a PMMS includes three phases (Nudurupati et al., 2011):

- Design: BSC (R. Kaplan & Norton, 2001; R. S. Kaplan & Norton, 1992), Performance Prism (Neely et al., 2002) and the Integrated Performance Measurement Systems (Bititci et al., 1997; Bititci et al., 1998) are examples of this phase output;
- Implementation, that include four main tasks: data creation, data collection data analysis and information distribution (Bourne et al., 2000);
- Use and update, with the former that is often considered cause of early failure of PMMS (Bititci et al., 2002) and the latter that is effectuated consistently with strategy updates, frequently needed in today's competitive environment (Bourne et al., 2000).

When developing a PMMS project and therefore going through these steps, it is necessary to face five main challenges, that together form a framework (Otley, 1999). They regard:

1) Identification of company's Critical Success Factors (CSFs) and decision about how to evaluate them;
2) Identification of company strategies, how to implement them and how to measure their performance;
3) Identification of the performance level necessary (target) in the two previous areas;
4) Assignment of rewards for managers when achieving the targets;
5) Decision upon which information flows are necessary to enable lesson learnt process.

This framework evolved in the following years in different ways, increasing its complexity. For example, Ferreira & Otley (2009) increased the number of steps up to 12. Anyway, the core is still the same. Frameworks presented in following dedicated sections, describing APM and BPA lifecycle, present similar phases.

A well-structured and adequately configurated PMMS is necessary to exploit data value and the techniques to analyze them (Silvi & Visani, 2016). It is therefore necessary for companies to employ dashboards for strategic control, directional control systems (e.g.

budget, variance analysis) and finally analytical systems for results analysis such as Total Cost of Ownership (TCO) or Activity Based Costing (ABC) (Silvi & Visani, 2016). All of these areas are recognized to be impacted from Big Data paradigm (Silvi et al., 2010; Silvi & Visani, 2016; Warren et al., 2015), but the few research present focuses on dashboards and BSC in particular (Appelbaum et al., 2017; Nielsen, 2017) or on analytical systems (Nielsen, 2017; Visani et al., 2016). No studies have been conducted on directional systems yet.

3.4 Second component: Information Technology (IT) infrastructure

IT and Information Systems (IS) evolved rapidly during the last decades, supporting increasing complexity levels of Business Intelligence and Analytics (BI&A). In particular, it is possible to classify three of them (Chen et al., 2012)

The first level can support structured data, usually stored in Relational Database Management Systems (RDBMS). A complete BI system should own 13 capabilities, classified in Integration, Information Delivery and Analysis capabilities (Hagerty et al., 2011). BI&A 1.0 can support reporting, dashboards, *ad hoc* query, search-based BI, OLAP, interactive visualization, scorecards, predictive modeling and data mining (H. Chen et al., 2012).

The second level, corresponding to BI&A 2.0, was born after the necessity of analyzing new type of unstructured data from the web. Usually, BI&A 1.0 are already integrated into commercial enterprise IT systems, while these new tools are not. They require to include mature and scalable techniques in text mining, web mining, social network analysis, and spatial temporal analysis with existing BI&A 1.0 RDBMS (H. Chen et al., 2012).

The third and last level, BI&A 3.0, is mostly related with smartphones and Internet of Things (IoT), that make possible to collect a much higher volume and variety of data. Not integrated solutions in enterprise systems are present yet, so that this is a great opportunity for further research both for academics and practitioners (H. Chen et al., 2012).

While RDBMS allow to manage structured data and implement BI&A 1.0, the technology that is mostly implemented to deal with Big Data and advanced BA is called NoSQL –

Not only SQL or, more recently, NewSQL. The former collects data without following the traditional relational scheme, allowing to manipulate more easily big amounts of unstructured data of different type. The latter uses a relational system, but provides scalability performances comparable to those of NoSQL systems (Osservatorio Big Data Analytics & Business Intelligence, 2017).

While many companies are now adopting proprietary systems (Osservatorio Big Data Analytics & Business Intelligence, 2017), a great input to research and development in this field as been given by open source systems. The most popular one is the Hadoop framework, together with its key component MapReduce (Baharu & Sharma, 2016; Chen et al., 2012; Zikopoulos et al., 2011). Hadoop is a "*Java-based framework that supports data-intensive distributed applications, enabling applications to work with thousands of processor nodes and petabytes of data*." (Stapleton, 2011). Its first key component is the Hadoop Distributed File System (HDFS), that is the concept of breaking down each cluster of data into smaller pieces called *blocks*, in order to more easily execute functions (Zikopoulos et al., 2011). The second one is MapReduce, a programming paradigm that allows for massive scalability across huge numbers of servers in a Hadoop cluster; the *map* task transforms data in set of *tuples* (key/value pairs), and then *reduce* allows to combine them in smaller sets (Zikopoulos et al., 2011).

Overall, the major challenge in Big Data is storage capacity, and it can be overcome through HDFS, while analyses can be carried out by MapReduce paradigm, that can process data across different clusters in parallel manner (Baharu & Sharma, 2016).

In general, IT investments that companies face can be categorized as (Osservatorio Big Data Analytics & Business Intelligence, 2017):

- *Enabling infrastructures*, including computational power, servers and storage facilities;
- *Software*, including databases, data acquisition and elaboration tools, data visualization and advanced data analytics platforms.

Software examples have been described before, when talking about RDBMS, NoSQL and NewSQL. On the other hand, considering infrastructures, one of the most important choices is about data integration level, that can be classified as follows (Osservatorio Big Data Analytics & Business Intelligence, 2017):

- *Silos*, that represents the traditional approach, where every function collects and stores its own data;
- *Data Warehouse*, that collects data, structured following relational schemes, coming from the whole organization and also external sources;
- *Data Lake*, that stores data in their native format and allows therefore integration of high quantity of data of every format and coming from every source.
- *Integrated model*, when the company owns both a Data Warehouse and a Data Lake, each one used depending on specific needs.

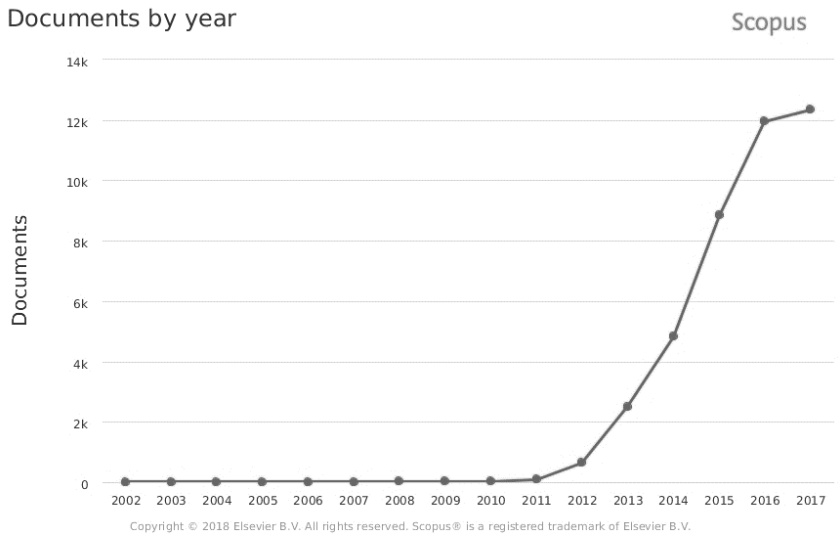
Industries leading in in investments are Banking (28%), Manufacturing (24%) and Telco and Media (14%). Investments growth, on the other hand, is higher than 25% in the Insurance, Banking and the Large Organized Distribution markets (Osservatorio Big Data Analytics & Business Intelligence, 2017).

3.5 Third component: Big Data

3.5.1 Research trends

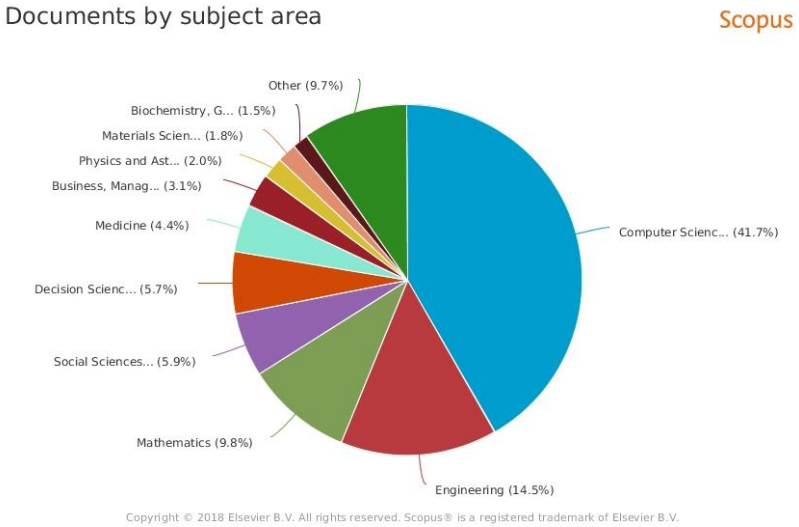
Among BPA components, Big Data is certainly the one on which researchers and practitioners are more talking about right now, and at the same time the most recent. For this reason, it is interesting to investigate research trends.

To have an overview about Big Data research, it is useful to analyze data coming from websites aggregating articles, books and other scientific documents from various journals and publishers. Scopus is one of these websites and enjoys a good reputation in terms of quantity and quality of documents stored, as mentioned also in the Literature Review Methodology chapter. The following graph shows the trend of documents including the keywords “Big Data”, published during the years. It has been arbitrary chosen as starting year 2002, since before this date no trend is present.



Graph 3-1, "Big Data" keyword search trend in Scopus database

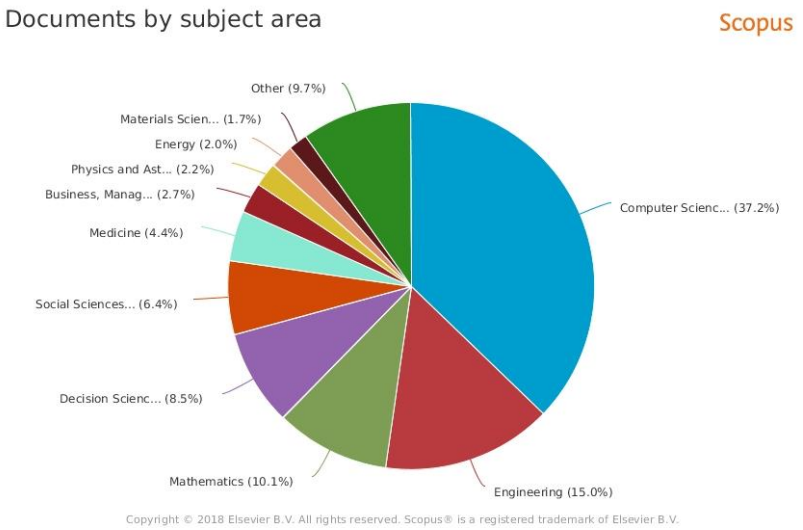
Graph 3-1 confirms what written in the Introduction chapter. Research about "Big Data" was very slow until 2011-12, when some key publications raised the interest in the whole scientific community. The peak has been reached in the last available year, 2017, with 12,334 documents available on Scopus. Up to date (20/08/18), in 2018 have been uploaded 9,109 documents, leading to think, considering a linear trend, that the amount at the end of the year will be similar. This also suggests that the interest in the topic may have reached a saturation limit, since from 2016 to 2018 the increase rate has decreased, compared to previous years. Another valuable analysis can be performed looking at documents distribution by subject, in the same years.



Graph 3-2, Subject areas of results from "Big Data" keyword search in Scopus database

Graph 3-2 shows that most of the research focuses on Big Data technical aspects. In fact, almost half of the documents (41,7%) is related to "Computer Science" subject area. Relevant shares belong also to other technical subjects such as "Engineering" (14,5%) and "Mathematics" (9,8%). This research is located in "Business, Management and Accounting" area. Numbers (only 3,1% of the documents regarding it) do not reflect the importance recognized to these topics from different studies, mentioned in the Introduction section and that will be further analyzed in the following ones.

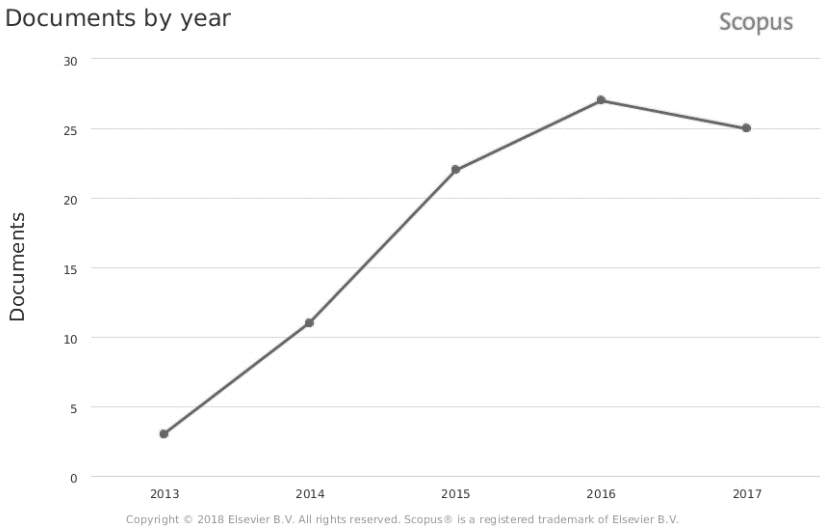
It is also possible to notice that, even increasing the analysis focus on a more recent period (2016-20, considering also papers which have been approved but not yet published), there are not considerable shifts in distribution among subject areas.



Graph 3-3, Subject areas of results from "Big Data" keyword search in Scopus database, 2016-20 period

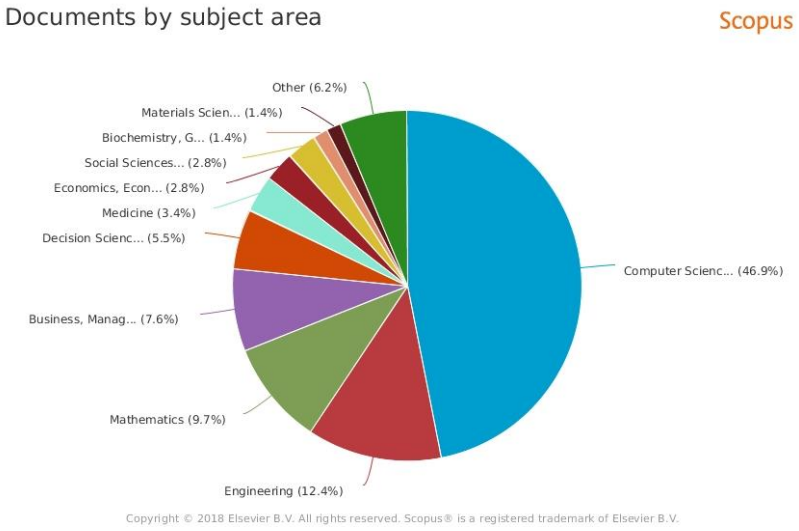
Actually, referring to *Graph 3-3*, "Business, Management and Accounting" area is even less relevant than in the previous case.

It is also possible to narrow down the analysis, considering only documents more strictly related to this research's topic. To do so, the previous analyses have been repeated with different keywords. This second search on Scopus used the keywords "Big Data" AND "performance management".



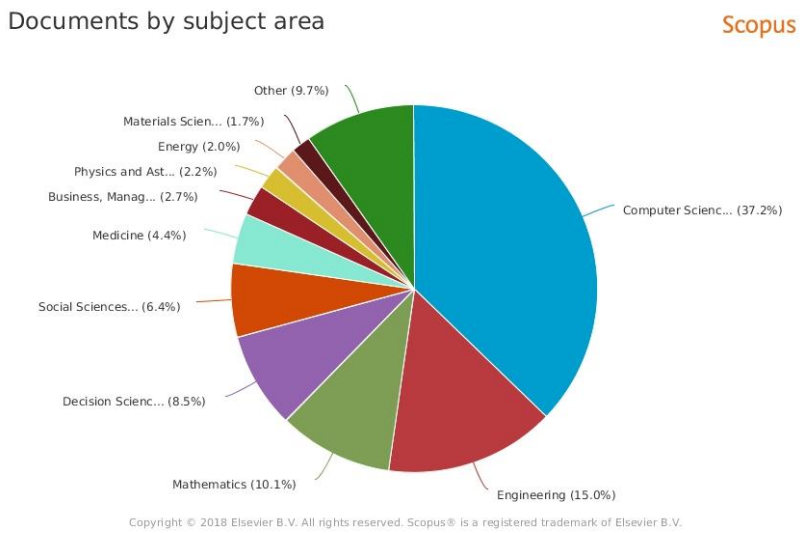
Graph 3-4, "Big Data" AND "Performance management" keywords search trend in Scopus database

Before 2013 no document was present on the database. Even in the following years, however, the number of publications has not reached significant volumes, especially if compared with the previous, broader, search.



Graph 3-5, Subject areas of results from "Big Data" AND "Performance management" keywords search in Scopus database

The analysis by subject in *Graph 3-5* shows that "Business, Management and Accounting" topic is, as expected, more relevant (7,6%) than before. Still, the share is low.



Graph 3-6, Subject areas of results from "Big Data" AND "Performance management" keywords search in Scopus database, 2016-18 period

For the sake of consistency, *Graph 3-6* shows the analysis by subject area repeated considering only the most recent documents (2016-18, no publication approved for 2019-20 yet). Conclusions are the same. There is only a slight decrease regarding "Business, Management and Accounting" subject area.

The analysis just presented does not include all documents published. For example, the only language considered is English. However, it is sufficiently comprehensive to represent and explain the worldwide research community interests. It shows that, despite the importance recognized to it, Big Data in Performance Measurement systems, ad therefore BPA, is not yet given enough attention and focus. This grants the author an opportunity to address a gap in existing literature.

3.5.2 **Introduction**

Big Data is the name used to call a new wave of data, that differentiates itself from the previous generation in terms of volume, variety and velocity (McAfee & Brynjolfsson, 2012). These differences are substantial and change the way how data should be managed and analyzed to effectively bring value to companies. Data, in fact, are only partially structured as it happened in the past; it is estimated that the highest volume is composed by unstructured data, such as videos (Gandomi & Haider, 2015). Text, audio, video and social media analytics are some of the methodologies now necessary to successfully exploit data available to companies (Gandomi & Haider, 2015). This exploitation can

bring substantial advantages to companies: it has been estimated that firms employing data-driven decision making, on average, are 5% more productive and 6% more profitable than competitors (McAfee & Brynjolfsson, 2012). How? The root reason stands in a famous sentence traditionally attributed to Peter Drucker: "*You cannot improve what you do not measure*". Big Data, together with Business Analytics, allow not only to collect, but also analyse data from an increased number of sources.

Big Data adoption, however, involves the whole company. It is a change of strategy, and it is therefore not enough to invest in IT technology to fully embrace it. Among others, it is needed a change in leadership, talent management, decision making and finally company culture (McAfee & Brynjolfsson, 2012). As any other strategic innovation, moreover, it requires all investments to be carefully aligned with business strategy and closely followed by the management with convincing engagement (Stefan Biesdorf, 2013).

Another aspect on which it has been put great attention is the need of a new role in organizations, the data scientist, who has not only a solid computer science background, but also soft skills such as communication, needed to effectively deliver the meaning of their analyses to managers (T. H. . Davenport & Patil, 2012), or the ability to ask the right questions and understand the limits of his analysis (McKinney et al., 2017). Accountants understand R&D, engineering, manufacturing unit activities and the marketing and sales function in relation to financial flows and perhaps also to a degree operationally: the accounting mind-set, therefore, provides a ready perspective on what could be asked if an appreciation of the potential of data analytics pre-exists (Bhimani & Willcocks, 2014). Increase in productivity can be achieved only with significant investments in expertise (Prasanna Tambe, 2014). The relevance of data scientist role tend to decrease the believe that "data speak by itself". (Mayer-Schönberger & Cukier, 2013). In general, it is considered necessary also complementary managerial knowledge about what is going on in the real world (Chang et al., 2014). There are studies concluding that even this enrichment of accountants skills is not enough, and that this role is destined to extinction (Frey & Osborne, 2013); this view, anyway, is considered pessimistic from other researchers: Big Data is not a threat, but an opportunity for controllers (Gary Cokins, 2014; Richins et al., 2016). From this second point of view, in fact, not only Finance function, and therefore accountants and controllers, is not going to lose any relevance,

but it is actually going to take on the role of CEO's "Strategic advisor" (Gary Cokins, 2014) and of "analytics leader" (T. H. Davenport & Tay, 2016).

Organizational models must also be defined. Data science will be an independent centralized unit, or decentralized? To what degree? Drivers of choice are not identified yet, but different solutions may be adequate depending on the context (Osservatorio Big Data Analytics & Business Intelligence, 2017).

3.5.3 Definition

It has been introduced what Big Data are, why they are important in today's world and main challenges that are faced when implementing them in a company. It is now necessary to formally define the concept. It is difficult to find a unique definition of Big Data in literature (Pospiech & Felden, 2012). Each author gives one, focusing on different aspects. Common characteristics included are data volume and variety of data sources.

<<*"Big Data" refers to enormous amounts of unstructured data produced by high-performance applications falling in a wide and heterogeneous family of application scenarios: from scientific computing applications to social networks, from e-government applications to medical information systems, and so forth* >> (Cuzzocrea et al., 2011).

This is an example entailing both concepts mentioned before. Authors highlight both the high volume of data ("*enormous amounts of unstructured data*") and then list some of the main sources from where they are generated.

Other definitions focus more on technological aspects of Big Data, and on the hardware necessary to handle and effectively analyze them. In an exhaustive report from McKinsey & Company, it is possible to find the following definition:

<<*"Big Data" refers to datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze*>> (Manyika et al., 2011).

This definition identifies four operations - capture, store, manage, analyze – that is not possible to perform with typical present technology, constituted by RDBMS and related tools.

Another interesting definition, presented below, is based on the same concept but gives an historical perspective.

<<Big Data should be defined at any point in time as data whose size forces us to look beyond the tried-and- true methods that are prevalent at that time>> (Jacobs, 2009).

Big Data, therefore, are not only those that nowadays require overcoming relational databases technology. In the 1990s, for example, any data for which Microsoft Excel was not enough, and hence requiring Unix workstations, could have been considered Big Data (Jacobs, 2009).

Boyd & Crawford, 2012 consider not only the technological and scholarly natures of Big Data phenomenon, but also the cultural one:

<< We define Big Data as a cultural, technological, and scholarly phenomenon that rests on the interplay of:

1) *Technology: maximizing computation power and algorithmic accuracy to gather, analyze, link, and compare large data sets.*
2) *Analysis: drawing on large data sets to identify patterns in order to make economic, social, technical, and legal claims.*
3) *Mythology: the widespread belief that large data sets offer a higher form of intelligence and knowledge that can generate insights that were previously impossible, with the aura of truth, objectivity, and accuracy.>>* (Boyd & Crawford, 2012)

These definitions show how different Big Data definitions can be, depending on the perspective adopted. However, for the purpose of this research, the most useful and comprehensive one has been developed by Fosso Wamba et al. (2015), who conducted a systematic literature review with the goal, among others, to summarize previous ones:

<<We define "Big Data' as a holistic approach to manage, process and analyze 5 Vs (i.e., volume, variety, velocity, veracity and value) in order to create actionable insights for sustained value delivery, measuring performance and establish competitive advantages>> (Fosso Wamba et al., 2015)

It is important to highlight as also this definition, integrating many others considered by the authors, considers "measuring performances" as one of the key value drivers of Big Data. Another topic included is Big Data "Vs". They are the characteristics on which this new paradigm differs from the traditional one. Already in 2001 (Laney, 2001) they have

been identified as critical parameters, causing difficulties in data storage, management and analysis.

3.5.4 **Characteristics**

An important classification of Big Data is based on their different formats and sources, that can be classified from a general point of view according to two dimensions (Silvi & Visani, 2016):

- *Structured* vs *Unstructured*: while the firsts can be stored in traditional RDBMS, the seconds need specific technologies; typical examples are ERP data vs video;
- *External* vs *Internal*: depending whether their source is inside or outside the company; examples can be tweets, Facebook posts vs costs, customers comments.

These two classifications lead to four categories, as clarified by *Table 3-1*, adapted from *Tavola 8* from Silvi & Visani, 2016. Examples are provided in each cell.

		Format	
		Structured	Unstructured
Source	Internal	> Market researches; > Sales data; > Process control metrics.	> Internal emails; > Customers comments; > Employees analyses.
	External	> Tweets numbers; > TripAdvisor ratings; > Location and time of tweets.	> Comments on online forums; > Video reviews; > Images on Pinterest; > Surveillance videos.

Table 3-1, Big Data classification in terms of Source and Format

Vs of Big Data

The "Vs" definition is very common in the terminology used among researchers, and it broadened along time, with the advent and diffusion of Big Data, about ten years after that first publication (G. Gupta & Gupta, 2015; Gandomi & Haider, 2015; McAfee & Brynjolfsson, 2012; Russom, 2011).

Volume

This concept has already been mentioned: it refers to the magnitude of data. It is often quoted the example of Wal-Mart, which collects every hour 2.5 petabytes of data from its customers transactions (Manyika et al., 2011; McAfee & Brynjolfsson, 2012). Facebook processes up to one million pictures per second (Beaver et al., 2010). Moreover, in the 2010s Web 3.0 is emerging, mobile and sensor-based, promising to further increase the number of data sources and therefore overall data amount (H. Chen et al., 2012). Nevertheless, it is difficult to define a volume threshold above which data become Big Data (Russom, 2011). It depends also on time and type of data: for current storage capacities could be "big" a quantity that in a few years becomes actually "small". Moreover, the same volume could be more or less difficult depending on the type of data, e.g. video or text (Gandomi & Haider, 2015). It has been argued that Big Data can bring great advantages and benefits to companies, since it is possible to know more about them and therefore improve performances and decision making (McAfee & Brynjolfsson, 2012). However, too many data could cause an overload of very complex information. In this scenario, information specialists could seek problems to which they can find a solution, instead of focusing real businesses problems (Bawden & Robinson, 2009). To avoid this kind of issues, it is necessary for data scientists to have a deep knowledge of the business they are working for, but it is difficult considering the background they are expected to have. According to T. H. . Davenport & Patil (2012), in fact, are required excellent skills in coding, communication and data visualization. Business and management come after these, but they are still necessary (Chang et al., 2014).

Variety

It is not recent for companies the opportunity to collect a great variety of data, thinking for example about social media and RFID tags, but it is only recently that companies want to exploit it (Gandomi & Haider, 2015; Russom, 2011). This variety is a continuum that extends from fully structured to unstructured data, passing by a great variety of semi-structured ones. Structured data are those present in relational databases, tables with columns and rows; semi-structured data are more difficult to define, but an example can be the XML format, that must be "dabbled" a bit, but then is machine-readable; unstructured data include videos, text, audios (Gandomi & Haider, 2015; Russom, 2011).

A first challenge caused by high variety is that different types of data require different types of visualization and representation; the best choice depends also on the decision maker, who best know what is necessary to highlight, and is therefore necessary to involve (Ask et al., 2016). Secondly, different visualization methods could lead to attention fragmentation in decision makers (Ask et al., 2016).

Velocity

Nowadays, it is common to collect real time data. Think about sensors on manufacturing machines, or security camera on the streets (Russom, 2011). The real challenge is not about quickly generating data, but about verifying, processing, storing, distributing, gleaning for insights, monitoring, updating and maintaining them with equal speed to really create value and therefore achieving competitive advantage (G. Gupta & Gupta, 2015). For example, a group of researchers from MIT tracked how many people were shopping at Macy's on Black Friday thanks to the GPS in their smartphones (McAfee & Brynjolfsson, 2012). Traditional data management system cannot be employed to perform this kind of tasks. Big Data technologies are needed to "*create real-time intelligence from high volumes of 'perishable' data*" (Gandomi & Haider, 2015). To achieve this goal, however, drawback must be considered and avoided. In fact, these new technology lead to integrate analytics in transactional data, and therefore "black-boxing" their functionalities and neglect their strategic and tactical nature (Ask et al., 2016).

Four levels of data analytics can be identified according to their velocity (Osservatorio Big Data Analytics & Business Intelligence, 2017):

- *Batch*, the system elaborates data collected periodically. An example is to elaborate during the night data collected during the day;
- *Near Real Time*, when data collected are elaborated by the system with intervals of hours or minutes;
- *Real Time*, when the system elaborates data as they are collected, and therefore they can be analyzed and consulted every time when needed;
- *Streaming*, when the system elaborates and produces analysis continuously during time.

Veracity

Veracity is a challenge in Big Data contexts that can arise when the data source is compromised, e.g. some machine sensors are damaged (Wang et al., 2016), or inherent into it. This is the case of social media and sentimental analysis, that can create value for companies but that nevertheless in unreliable in nature (Gandomi & Haider, 2015). This issue can have consequences, especially regarding poor decision making, that can cause also life loss in life monitoring applications (G. Gupta & Gupta, 2015). Low veracity of data can not only do not bring value to business, but even damage it (G. Gupta & Gupta, 2015; Jamil et al., 2015). There are specific tools used to deal with this Big Data characteristic (Gandomi & Haider, 2015).

Value

It is related to the huge potential value that Big Data can generate for companies (Ask et al., 2016; Fosso Wamba et al., 2015; G. Gupta & Gupta, 2015). However, there is also another side other than the "potential value", and it is the "low density" of value (Gandomi & Haider, 2015; Wang et al., 2016). How data scientists use analytics is therefore key to extract it. Another aspect that should be considered is that value can be relative: some data can be important today, but not tomorrow; others are not today but can be valuable next month (G. Gupta & Gupta, 2015).

The "V" dimensions are not independent, but they can influence each other (Gandomi & Haider, 2015). If one changes (e.g. increase in velocity), most likely another one, or more, will change as well (e.g. most likely increase in volume). Some researchers extended the paradigm even further, arriving to include 8 Vs, adding Validation, Visibility, Vision (G. Gupta & Gupta, 2015). However, at the moment, they lack adequate support from literature. It may be interesting in the future to repeat this literature review, to check if more researchers will adopt them.

3.6 **Fourth component: Business Analytics**

Business Analytics is:

<<The use of data, information technology, statistical analysis, quantitative methods, and mathematical or computer-based models to help managers gain improved insight about their operations, and make better, fact-based decisions>> (T. H. Davenport, 2008).

Business Analytics concept is often considered an evolution of Business Intelligence (BI), born in the 2000s to highlight the new key analytical component (H. Chen et al., 2012). While BI is a term coming from IT that traditionally focuses on the ETL (Extract, Transform, Load) process of data (T. H. Davenport, 2006) and on business measurement (Shi & Lu, 2010), BA allows to create and maintain data repository for new type of data (Big Data) with the ultimate aim of extract value from them supporting knowledge acquisition, insight generation, problem finding, and problem solving to assist decision making (Holsapple et al., 2014).

Analyzing BA, it is possible to identify three kinds of dimensions and six different perspectives (Holsapple et al., 2014). In the domain of this research, however, it is most considered the Orientation dimension, focusing on descriptive, predictive and prescriptive analytics taxonomy (Appelbaum et al., 2017; Nielsen, 2017; Raffoni et al., 2017).

3.6.1 **Descriptive analytics**

Descriptive analytics are the simplest form of BA, and involve the summarization and description of knowledge patterns using simple statistical methods, such as mean, median, mode, standard deviation, variance, and frequency measurement of specific events in Big Data stream (Rehman et al., 2016). They use historical data to identify patterns and create management reports, and hence concerned with modelling past behaviour (Assunção et al., 2015). The questions they help to answer, therefore, regard what happened in the past. For example: “What was the sales revenue in the first quarter of the year? Is additional sales effort needed to meet our target?”, or “Which is our most profitable product/region/customer?” (Furht & Villanustre, 2016). Cost reporting and analysis is another example of descriptive analytics (G Cokins, 2013a). Their output can be a useful input for other types of analytics, and this is why they are often considered a preliminary step (Raffoni et al., 2017). Visualization tools, such as different types of graphs and pivot tables, can be extremely important to this goal (Nielsen, 2017). Most of Big Data analytics is commonly descriptive (exploratory) in nature and the use of descriptive statistical methods (data mining tools) allows businesses to discover useful patterns or unidentified correlations that could be used for making business decisions (Sivarajah et al., 2017).

3.6.2 Predictive analytics

Predictive analytics comprise a variety of techniques that predict future outcomes based on historical and current data, seeking to capture pattern and uncovering relationships (Gandomi & Haider, 2015). The questions they help to answer, therefore, regard what will happen in the future. For example: "What will the number of complaints to our call centre next quarter?" or "Which customers are most likely to churn (e.g. cancel her subscription)?" (Furht & Villanustre, 2016). One relevant trend in accounting is the shift from descriptive to predictive analytics, and therefore from cost analysis and reporting, that is about explanation, to decision support with cost planning, that is about possibilities (G Cokins, 2013a). Predictive analytics are useful to foresight future events, but do not suggest actions; they provide enhanced insights to managers, so that they can make informed decisions (IBM, 2013). It has been suggested that Big Data will require new and advanced predictive techniques, because of some peculiarities they have (Gandomi & Haider, 2015):

- They often represent the whole population and not one sample, therefore the concept of statistical significance loses its meaning;
- Traditional techniques do not scale up easily to Big Data volumes;
- Distinctive features of Big Data (heterogeneity, noise accumulation, spurious correlation and incidental endogeneity) need to be considered when applying predictive analytics on Big Data.

There are several classifications of techniques in literature. For example (Rehman et al., 2016):

- Machine learning methods, further classified as supervised, un-supervised and semi-supervised learning methods;
- Data mining methods, further classified as classification, association rules mining and regression analysis.

According to a research by IBM, companies employing analytics to take informed decisions are twice as likely to outperform their rivals in the industry (IBM, 2013).

3.6.3 Prescriptive analytics

This orientation of analytics is performed to determine the cause-effect relationship among analytic results and business process optimization policies (Sivarajah et al., 2017). The question answered from prescriptive analytics is: "What should we do?"; it explores a set of possible actions and suggests which one to select based on descriptive and predictive analyses of complex data. Though the final decision is up to the facilities and asset manager, prescriptive analytics solutions can provide a reliable path to an optimal solution for business needs or resolution of operational problems (Holsapple et al., 2014; IBM, 2013). In fact, often alternatives are just too many to be all considered by a human decision maker (Nielsen, 2017). Examples of solutions which they can provide to possible issues are: "We know that this person has a high chance to churn, we can offer her a value package", or "We know the viewing history of this customer on our news site, we can recommend articles that we think she would like to read next" (Furht & Villanustre, 2016). Techniques used for predictive and prescriptive analytics may look similar; the most evident difference is in the variety of data needed and the orientation (Appelbaum et al., 2017). The higher the variety, the higher will also be the prescription ability; the orientation is prescriptive if an optimization query is performed, while it is predictive if a trend-based analysis is. Another important characteristic of prescriptive analytics is that they can provide a feedback loop to the prediction process: Big Data can enhance the feedback, leading to great improvement (Appelbaum et al., 2017). In general, prescriptive solutions assist business analysts in decision-making by determining actions and assessing their impact regarding business objectives, requirements, and constraints. For example, what-if simulators have helped to provide insights regarding the plausible options that a business could choose to implement, in order to maintain or strengthen its current position in the market (Sivarajah et al., 2017).

An overall comprehensive classification of Business Analytics techniques is provided by Appelbaum et al., 2017, as *Table 3-2* shows.

The orientation and techniques of business analytics in the managerial accounting domain, where:

D, PD, PS = descriptive, predictive, prescriptive.

E, C = exploratory, confirmatory.

S, SS, U = structured, semi-structured, unstructured.

QN, QL = quantitative, qualitative.

D, S = deterministic, statistical.

Orientation	Techniques		Technique type			
Descriptive (D) Predictive (PD) Prescriptive (PS)			Exploratory (E) Confirmatory (C)	Structured (S) Semi-structured (SS) Unstructured (U)	Quantitative (QN) Qualitative (QL)	Deterministic (D) Statistical (S)
D	Basic accounting analysis	Ratio Analysis	C	S	QN	D
D	Unsupervised	Clustering Models	E	S	QN	S
D		Text Mining Models	E	SS, U	QL	S
D		Visualizations	E	SS, U	QL, QN	S
D		Process Mining: Process Discovery Models	E	S, SS	QN	S
PD	Supervised	Process Mining: Process Optimizations	C	S, SS	QN	S
PD		Support Vector Machines (SVM)	C	S	QN	S
PD, PS		Artificial Neural Networks (ANN)	C	S	QN	S
PD, PS		Genetic Algorithms	C	S	QN	S
PD, PS		Expert Systems/Decision Aids	C	S, SS, U	QN, QL	S
PD		Bagging and Boosting Models	C	S	QN	S
PD		C4.5 statistical Classifiers	C	S	QN	S
PD		Bayesian Theory/Bayesian Belief Networks (BBN)	C	S	QN	S
PD		Dempster-Shafer Theory Models	C	S	QN	S
PD		Probability Theory Models	C	S	QN	S
PD. PS	Regression	Log Regression	C	S	QN	S
PD, PS		Linear Regression	C	S	QN	S
PD, PS		Time Series Regression	C	S	QN	S
PD, PS		Auto Regressive Integrated Moving Average (ARIMA)	C	S	QN	S
PD, PS		Univariate and Multivariate Regression Analysis	C	S	QN	S
PD	Other statistics	Multi-criteria Decision Aid	C	S	QN	S
PD		Benford's Law	C	S	QN	S
D		Descriptive Statistics	E	S	QN	S
PD		Structural Models	C	S	QN	S
PD		Analytical Hierarchy Processes (AHP)	C	S	QN	S
D		Spearman Rank Correlation Measurements	E	S	QN	S
PD		Hypothesis Evaluations	C	S	QN	S
PD, PS		Monte Carlo Study/Simulation	C	S	QN	S

Table 3-2, Comprehensive classification of Business Analytics methods (Appelbaum, 2017)

About this table, authors also highlight that the most traditionally used accounting techniques are quantitative, statistical, and based on structured data; a second point is that some new techniques, originating for example from machine learning and artificial intelligence fields, do not make statistical assumptions on data and therefore generate not statistical models (Appelbaum et al., 2017).

According to a previous survey, answered from a sample of 159 Italian companies with more that 249 employees, 100% of firms adopts descriptive analytics. The percentage of

companies employing predictive analytics is still high, equal to 73%, while only 33% of companies states that prescriptive analytics are common practice (Osservatorio Big Data Analytics & Business Intelligence, 2017). It is important to highlight, however, how these data do not regard Finance function, but the company as a whole.

3.7 Analytical Performance Management (APM) and Business Performance Analytics (BPA)

The exploitation of Big Data analytics in Performance Measurement systems has a recent history in academic research, and still no standard nomenclature has been established. It has been called, depending on specific contexts and applications, Business Performance Analytics (BPA) (Raffoni et al., 2017; Silvi & Visani, 2016), Management Accounting Data Analytics (MADA) (Appelbaum et al., 2017), Performance Measurement Analytics (PMA) (T. H. Davenport, 2008; Schläfke et al., 2012) or Analytics Performance Measurement (APM) (Nielsen, 2017; Silvi & Visani, 2016). Even though some of them, as already mentioned at the beginning of literature review chapter, express different but related concepts, the nomenclature ambiguity is another hint suggesting that research on the topic is still in its infancy.

However, all definitions converge, highlighting the same core concepts. According to a diffused definition stated at the beginning of Big Data research, APM is

<<*The extensive use of data and analytical methods to understand relevant business dynamics, to effectively control key performance drivers, and to actively increase organizational performance*>> (Schläfke et al., 2012).

As already mentioned in previous chapter, Analytical Performance Management is considered an approach, that exploits a collection of models called Business Performance Analytics. The two concepts, nevertheless, are overlapping, and to do not create confusion in this research only one name will be used from now on. Since the focus is on practical application rather than on the approach, the nomenclature used will therefore be Business Performance Analytics. BPA definition is here reminded. It consists of

<<*Models supporting performance monitoring and management, that help understanding business dynamics and strategies through*>> (Silvi & Visani, 2016).

Models different from the one presented before (Silvi & Visani, 2016) are present in literature. Nielsen, 2017, considers APM as the intersection of three disciplines (Nielsen, 2017):

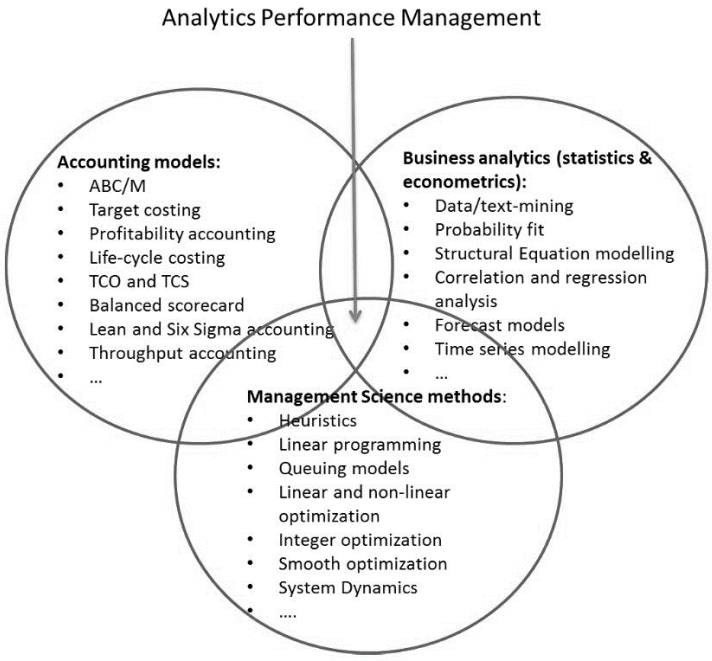


Figure 3-2, APM as the intersection of multiple disciplines (Nielsen, 2017)

Now it is clear how, more in general, BPA is the application of Business Analytics techniques with the goal of Performance Measurement. IT technology and infrastructure are the key enabler, while Big Data are a new paradigm allowing greater potential.

3.7.1 BPA implementation

There are few examples in literature where BPA implementation is analyzed in literature. Some papers propose frameworks, leaving testing to further research (Appelbaum et al., 2017; Schläfke et al., 2012); others follow this type of projects in companies without addressing the problem explicitly as BPA (Dutta & Bose, 2015; Vallurupalli & Bose, 2018); other studies observe system applications in a company, without considering the implementation process (R. G. S. de Mello, et al., 2015); finally, some develop a BPA implementation framework and then test it in a real exploratory case study (Kourtit & Nijkamp, 2018; Raffoni et al., 2017; Visani, 2017; Visani et al., 2016) However, they do not analyze how controllers' activities improve, or in general how does the complete system generate value in companies. These studies cover a wide range of industries and

PMMS areas. For example, they can focus on dashboards for i-cities, exploring the case of Stockholm (Kourtit & Nijkamp, 2018), or Total Cost of Ownership for procurement choices in an Italian medium-sized company operating in mechanical engineering industry (Visani et al., 2016). Others focus on specific performance management tools, mostly the popular Balance Scorecard for dashboards applications (Appelbaum et al., 2017; Nielsen, 2017). For each area there are only few papers, and it is therefore research is still needed in each of them.

Papers can therefore be classified according to two dimensions:

1) Scope extent → A continuum ranging from "Specific tool" to "APM as a whole";
2) Approach → A continuum ranging from "Practical" to "Theoretical", from understanding how they work inside the company to their general functions.

Table 3-3 classifies some of the researches just mentioned according to these two dimensions:

		Approach	
		Theoretical	Practical
Scope	Specific tool	Appelbaum (2017)	Visani et al. (2016); Nielsen (2017)
	BPA as a whole	Silvi & Visani (2016); Warren et al., 2015 Silvi et al. (2010); Schläfke et al. (2012)	Raffoni et al. (2017); Visani (2017);

Table 3-3, Core papers classification highlighting a gap in literature

Table 3-3 summarizes consideration presented above, showing that exist two studies adopting a practical approach and analyzing the BPA system as a whole. However, Raffoni et al. (2017) and Visani (2017) do not consider impacts controllers' daily activities, but macro-steps of BPA implementation.

Considering BPA as a whole, one of the studies adopting an approach more practical among the aforementioned, is the one conducted by Raffoni et al. (2017), that summarizes previous works from the same team. The purpose of the research is to provide a practical

framework describing the implementation process. In fact, the theoretical focus is identified as the main limit of previous papers (Appelbaum et al., 2017; Schläfke et al., 2012; Silvi et al., 2010). Hypothesising a different contribute of BPA from diagnostic and interactive use (Simons, 1995), they first developed a preliminary framework that was later confirmed and detailed from an on-site case study. Here it is presented the sequence of steps recognized:

1) Business Strategy and Performance model assessment;
2) Key Questions;
3) Data Collection;
4) Data Analysis;
5) Performance Management Cycle.

Comparing them with the process described by Otley (1999), and previously presented in the Literature Review chapter, it is possible to notice that in both of them is emphasized the strategy assessment, but only in Raffoni et al. (2017) Data Collection and Data Analysis are made explicit and given high relevance. The paper provides step towards BPA implementation grounded in reality, but still generic, not giving insights on the specificity of system's components, on which controllers' activities are improved and how.

Appelbaum (2017), shows another side of the APM and BPA research. In fact, the researcher considers one precise tool in PMM, that is the Balance Scorecard, and develops a theoretical framework, that he names Management Accounting Data Analytics (MADA). The framework describes how to apply descriptive, predictive and prescriptive analytics in the Financial, Customer, Internal Process and Learning and Growth perspectives. Compared therefore with Raffoni et al. (2017), Appelbaum (2017) provides an insight on a much more specific area, but lacks an empirical study.

Nielsen (2017) attempts to bridge the gap between theory and practice but focusing on specific PMM tools. He chose a combination of them and proved the positive impact that Business Analytics can deliver. He combined Time-Driven Activity Based Costing (TD-ABC) and the BSC. Then, he applied prescriptive analytics in the solving stage, demonstrating the complexity but also opportunities of this approach. Which action to take must be based on insight, degree of risk, and the level of decision conservativism,

e.g. going from 30th-percentile to 12th-percentile level focusing on the probability of a Return of Capital Employed (RoCE) below zero, as shown form Nielsen's simulation. Again, this research does not consider the impact of BPA innovation from a systematic point of view.

3.8 BPA Benefits and Challenges

An analysis of benefits and challenges brought by BPA is necessary to understand why companies start these projects, and what actions they must take to be successful.

3.8.1 Benefits

When analyzing companies' practices and methodologies in a specific process, it is important to know which benefits they are seeking. Big Data and Business Analytics have been recognized to have great potential for companies and specifically PMMSs. The advantages they can bring are cross-sectorial, and can be exploited from digital native companies as well as traditional businesses (McAfee & Brynjolfsson, 2012; Raguseo, 2018). The main categories are summarized in this chapter. They are clearly dependent on each other and have been organized grouping existing literature findings.

Improved decision-making process

Big Data can unlock significant value by making information transparent and usable at a much higher frequency; more people looking at the data, together with sophisticated Business Analytics, will bring more perspectives and solution and ultimately improved decision making process (Fanning & Grant, 2013; Osservatorio Big Data Analytics & Business Intelligence, 2017). Decision-making process can become faster and more accurate if BPA are implemented successfully, thanks to better integration or fusion and subsequent analysis of quantitative and qualitative data (Tien, 2013). At the same time, they make easier to identify rare events that can nevertheless have a great impact, the so-called "black swans" (Tien, 2013). More information may lead to more "messy" findings but yet good to support informed decision (Tien, 2013). Authors envision that Big Data Analytics will make possible to make smarter decisions, targeting more effective interventions (McAfee & Brynjolfsson, 2012; R. Mello et al., 2014). Data-driven decision making is enabled also when traditionally is more important managers' intuition (McAfee & Brynjolfsson, 2012; Tien, 2013; Wamba et al., 2017). New data sources are in fact available to be processed and analyzed, leading ultimately to improved firms

performance (Wamba et al., 2017). Companies in the top third of their industry in the use of data-driven decision making were, on average, 5% more productive and 6% more profitable than their competitors (McAfee & Brynjolfsson, 2012).

Process optimization

Studies proved that Big Data Analytics have a positive impact on firms Process Oriented Dynamic Capabilities (PODC), referring to the extent to which a firm can develop or acquire required competences to change its existing business processes in a more robust way than its competitors, in terms of coordination, integration, cost reduction and business intelligence and learning related to BDA projects (Wamba et al., 2017). Organizational agility, that is the firm capability to adapt efficiently and effectively its processes to value creation and consolidation, is also impacted from BDA implementation (Côrte-Real et al., 2017). Part of Finance processes can be optimized through Robot Process Automation (RPA), that is enabled by Business Analytics. Examples are basic reporting, cash management, account reconciliation, allowing therefore to save headcounts (Accenture, 2018; Network Digital 360, 2017; Plaschke et al., 2018).

Product optimization

The large organized distribution example provided in the previous paragraph makes clear that customers satisfaction can be improved, thanks to a better understanding of their needs and therefore allowing to design and deliver products they really need (Freeman & Spenner, 2012; McAfee & Brynjolfsson, 2012). This can be performed with a very high level of detail, dividing customers in small segments and tailoring for each of them products and services (Fanning & Grant, 2013; Zwitter et al., 2013).

Cost reduction and profit margins increase

It is recognized that Big Data and Business Analytics can increase system and system-of-systems efficiency and effectiveness (Tien, 2013). Operational efficiency is believed to be an advantage from 51% of enterprises (C. L. Chen & Zhang, 2014). IT infrastructure improvement may lead to increased costs, but this effect can be prevented exploiting Cloud computing (Assunção et al., 2015), used currently from 64% of Italian companies (Osservatorio Big Data Analytics & Business Intelligence, 2017). McAfee &

Brynjolfsson (2012), reports an example of a major U.S. airline, which turned from measuring the Expected Time of Arrival (ETA), a key performance in the industry, from pilot information to a new algorithm including data about weather, flight schedules and other proprietary ones. This allowed to virtually eliminate the gap between estimated and actual ETA, saving several millions of dollars per airport. Other examples in the large organized distribution show how more tailored promotions can be developed, and then faster delivered, leading to lower costs, increased revenues and ultimately to better margins.

3.8.2 **Challenges**

In the analysis of companies' methodologies and applications of BPA, it is important to keep in mind which difficulties they are facing. The many potential advantages presented can be exploited only overcoming several barriers and challenges, descriptions of which can be found in existing literature. Despite different classifications are possible, two main groups are identified: technological and managerial challenges.

Technological challenges

Big Data and Business Analytics are a new paradigm based on technology as enabler; the management revolution must be therefore accompanied by a technological revolution (McAfee & Brynjolfsson, 2012). Challenges in Big Data analysis include data inconsistence and incompleteness, scalability, timeliness and data security, meaning that prior to data analysis, data themselves must be well-constructed; after that, difficulties arise in efficient analysis, representation and visualization of huge amount of unstructured and semi-structured data, characterized from great variety (C. L. Chen & Zhang, 2014). Concerns therefore exist in all phases of the process: acquisition, access, analytics and application (C. L. Chen & Zhang, 2014; Tien, 2013). Selection of the technology itself is considered to be a challenge (Vidgen et al., 2017), given also the level of uncertainty still present in the field (Raguseo, 2018).

Managerial challenges

This category includes a wide range of challenges. Firstly, talent management is often considered in literature as one of the greatest barriers to achieve effective BPA implementation, because of the mix of skills required to new modern accountants, including not only traditional ones but also deep comprehension of the business, good

communication and a computer science background (T. H. . Davenport & Patil, 2012; McAfee & Brynjolfsson, 2012; McKinney et al., 2017; Raguseo, 2018; Vidgen et al., 2017). Secondly, there is the need of a complete cultural shift of firms, beginning from the leadership and then involving all the underlings, shifting from a "what do we think?" "what do we know?" mindset, avoiding to base decision on managers guts (DalleMule & Davenport, 2017; T. Davenport, 2017; T. H. Davenport & Bean, 2018; McAfee & Brynjolfsson, 2012). Employees will tend to resist change, and appropriate actions must be taken to address the issue (Vidgen et al., 2017). Thirdly, privacy and ethics cannot be neglected, considering also recent scandals such as Cambridge Analytica involving Facebook, that can damage companies' brand and reputation (T. H. Davenport & Harris, 2007; Fanning & Grant, 2013; Raguseo, 2018; Rikhardsson & Yigitbasioglu, 2018; Vidgen et al., 2017). Raguseo (2018), affirms that Privacy is the most mentioned risk from managers. It is important to consider that actually privacy is not only a managerial problem, but also technological, implying that adequate encryption model must be adopted by firms to protect customers data from external threats; on the other side, regulators should provide guidelines (Fanning & Grant, 2013). Another challenge that slows down the investment process is the difficulty in estimating investments benefits (Osservatorio Big Data Analytics & Business Intelligence, 2017).

3.9 **Summary**

From the literature review, emerged that relevant gaps exist in research. Despite the relevance of BPA it has been recognized from 2010 (Silvi et al., 2010), only recently focused and empirical studies have been published (Appelbaum et al., 2017; Nielsen, 2017; Raffoni et al., 2017; Visani et al., 2016). Components presented as key from Silvi & Visani (2016), all have a research history. PMMS studies can be tracked to the 50s (Nudurupati et al., 2011); Big Data has been the last topic to raise interest, starting from the 2010s, reaching anyway an incredible hype as it is possible to see from *Graph 3-1* and *Graph 3-4* in the corresponding Literature Review chapter. Also IT infrastructures, in relation to PMMS, is a well-known and analyzed subject in research, with studies following their evolution through history (H. Chen et al., 2012); finally, comprehensive studies about Business Analytics exist as well (Holsapple et al., 2014). What still is waiting to be addressed from research is how their simultaneous implementation are

changing and improving traditional companies processes in management control. This is noticeable also from *Table 3-3*. The planning and control cycle is the perfect example of this gap. Recognized to be greatly impacted from Big Data and analytics (Silvi & Visani, 2016; Warren et al., 2015), still no theoretical framework or empirical study has been published addressing it. Anyway, other activities typically belonging to controllers are still neglected in literature and should be considered when aiming at developing a comprehensive framework. Moreover, while exist studies analyzing BPA implementation process and suggesting how to overcome challenges, especially managerial (Dutta & Bose, 2015; Raffoni et al., 2017; Vallurupalli & Bose, 2018), and others describing specific applications (Appelbaum et al., 2017; Nielsen, 2017; Visani et al., 2016), no framework supporting companies gaining a comprehensive view of which activities they can improve implementing BPA and how exist.

4. OBJECTIVES AND METHODOLOGY

4.1 Research Questions

Research questions have been developed aiming to better comprehend characteristics of BPA that have been partially or not investigated at all in existing literature. In fact, as it has been highlighted in the literature review summary, is clear that one of the most important gaps is about an overall and comprehensive view of BPA, including not only all its components but also their impact on different controllers' activities and on the company overall. *Table 3-3* suggestions follow the same rationale. Comprehensive studies conducted in the recent past regard the implementation process (Raffoni et al., 2017), not addressing how the system works and brings value to the company.

RQ 1

The first research question tackles directly BPA and its components, looking for information of both managerial and technical nature. In fact, building on Silvi & Visani, 2016, in the literature review has been showed that different types of IT infrastructure, Big Data and Business Analytics exist and are well studied from a theoretical point of view. However, their diffusion and configurations in the market are not clear. This research question aims therefore at clarifying this point.

<< What is the degree of diffusion of BPA systems among companies, in terms of key components (PMMS, IT infrastructure, Business Analytics, Big Data)?>>

From literature review we know that BPA is complex to implement in companies, because of investments needed in IT, analytical skills, cultural shift. For this reason, it is expected to find advanced solutions, implementing NoSQL or NewSQL systems and analyzing both structured and unstructured data mainly in big companies, most likely if digital native because already closer to the needed mindset.

RQ 2

The second research question aims at investigating how configurations identified in the first one impact controllers and their daily activities, adopting therefore a managerial perspective. In the Literature Review chapter dedicated to APM and BPA studies, it has been highlighted how much time has been dedicated understanding the implementation

process, challenges and advantages, but very few investigated new dynamics affecting controllers' activities in a fully or partially implemented system.

<< How do BPA improvement areas impact controllers' activities?>>

Researches, on the other hand, presented in previous chapters detailed which new competencies they should acquire in order to embrace Big Data and Business analytics in their activities, and therefore BPA (Brands & Holtzblatt, 2015; T. H. . Davenport & Patil, 2012; McKinney et al., 2017). The analysis of this literature, included in the dedicate chapter, will be helpful answering *RQ 2*.

RQ 3

The third research question, on the other hand, wants to understand why BPA projects are kicked off in companies, which missions are lying behind them. Advantages and benefits sought from companies actually have been widely investigated (for example: Court, 2015; McAfee & Brynjolfsson, 2012; Raguseo, 2018). However, other researches adopted mostly quantitative structured surveys regarding Big Data and Business Analytics but not focused on BPA, or singular detailed case studies in specific scenarios. The methodology adopted in this Master Thesis effort is different and therefore aims at gaining a new perspective about the topic, considering relationships between them and different configurations in different companies.

<<Which advantages are pursued from companies implementing a BPA system?>>.

4.2 Methodology

The methodology is consistent to the research status of the topic, still in its infancy. A quantitative extensive study in this situation would not give significant result, since in the industry only few companies are expected to have implemented an extensive BPA system, and it is therefore not possible to develop a questionnaire clear for all respondents. This is true especially in Italy, where 95% of companies have less than 10 employees (Confcommercio, 2009). In fact, company size is expected to be directly related with the use of analytics, because of the huge investments needed (Llave, 2017). The researcher actually designed and prepared a structured survey on Opinio, an online software often used from Politecnico di Milano's Osservatori with similar purpose; however, it was not

validated by preliminary interviews with field experts and practitioners, presented below, because of the afore mentioned reasons.

- S. L., Senior Manager at Accenture – Capability Network;
- E.R., Sales Development Director, Digital Finance & Supply Chain Solutions at Oracle;
- G. C., President of respected national controllers association;
- G. Co., Founder and CEO of consulting company focused on Analytics-Based Performance Management; Expert in ABC, EPM/CPM, Profit Analysis, Budget, Analytics, published several articles on Strategic Finance Magazine;
- Researchers at Politecnico di Milano's Osservatorio Big Data Analytics and Business Intelligence.

Therefore, in this study, it has been selected a qualitative research methodology, because existing literature has only focused on theorization and formulation of expectations, and insights from practice about these theorization and expectations are missing. This means that only limited qualitative research has been done that have led to practical insights about BPA, in which areas it can benefit controllers and how. This research examines the expectations present in existing literature and, doing so, it can obtain deeper insights from practice. Qualitative research focuses on collecting specific information from a small group. Based on this, one framework is built to give an illustration and an explanation of the impact that BPA has in companies. Qualitative research focuses on the socially constructed nature of reality, in order to rule on patterns and processes which underlie this phenomenon and stresses the situational constraints that may constitute the research (Denzin & Lincoln, 2018). The goal of qualitative research is not to adopt general laws, but to investigate different effects. However, as a result generalizability of qualitative studies is lower (Abernethy et al., 1999). A qualitative approach such as interviews is suitable for studies in areas in which limited research has been done and qualitative research is suitable in studies that investigate and explain complex situations (Saunders et al., 2009). Therefore, this approach is appropriate for this study because within existing literature the impact of BPA on companies and its applications have received only minor attention, and the relationships among techniques, activities and benefits may be difficult to be examined in practice. Moreover, these relations seem to be complex in practice,

because of the nature of BPA paradigm as the intersection of multiple disciplines such as management control, computer science and analytics.

4.2.1 **BPA Framework**

The first step of the research is to build a theoretical framework, the purpose of which is to serve as a backbone to exploratory case studies. It organizes the literature accordingly with problems formulated through research questions and will be used as a guideline during interviews. It is composed by primary and secondary blocks, and relationships existing among them. In *Figure 4-1* is given a view of primary blocks.

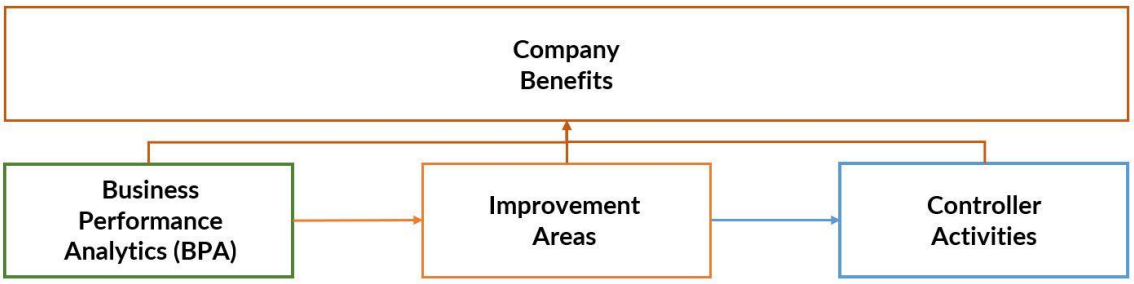


Figure 4-1, BPA framework primary blocks

It aims to explain how a specific BPA system configuration (*RQ 1*) can bring which improvements to a list of controllers' activities (*RQ 2*). Finally, which benefits do BPA and its improvements to controller activities bring to the company as a whole (*RQ3*)? The output is descriptive and robust thanks to a detailed and comprehensive analysis and re-organization of existing literature. This process includes not only research papers, but also white papers written from authoritative and trustable sources such as international consulting firms. They are closer to companies needs and can therefore provide key details in specific areas. Anyway, as it has already been mentioned, existing literature does not provide bases solid enough. Therefore, interviews have been conducted with experts and practitioners in the field, to obtain final suggestions and validation of the framework. Interviewees are the same who led to the decision to avoid a quantitative survey, presented at *page 47*.

4.2.2 **Exploratory case studies**

After the backbone, constituted by the framework, has been developed, exploratory case studies build on it, answering research questions. Companies have been selected aiming at creating an heterogenous sample in terms of size and industry. In fact, these two factors

could lead to different implementation levels and structure of BPA systems (Llave, 2017; Network Digital 360, 2017). This goal has been achieved; eight companies have been studied, and their peculiarities are presented one by one in the following chapters.

Interviews have been conducted following a semi-structured approach. Compared to structured interviews, semi-structured interviews can make better use of the knowledge-producing potentials of dialogues by allowing much more leeway for following up on whatever angles are deemed important by the interviewee; as well, the interviewer has a greater chance of becoming visible as a knowledge-producing participant in the process itself, rather than hiding behind a pre-set interview guide. And, compared to unstructured interviews, the interviewer has a greater say in focusing the conversation on issues that he or she deems important in relation to the research project (Leavy, 2014). The approach is semi-structured because questions are defined from the framework; at the same time, a high degree of freedom was given to the interviewee answering, since each company developed some areas of BPA, leaving others still to be explored. Case studies were therefore directed towards what was already structured and implemented.

Interviewees are either controllers, responsible of company innovation and digitalization or executives. All of them has a comprehensive view of their employer business, Finance function and analytics projects.

Therefore, the interview process has been structured according to the following macro-steps:

1) Brief introduction of Master Thesis subject via email/phone;
2) BPA framework presentation and explanation face to face;
3) Ask interviewee to briefly introduce the company he is working for, together with business and market peculiarities:
4) Ask the interviewee to comment BPA applications currently present in the company and future projects, providing feedbacks about framework clarity and completeness;

Great freedom was given to interviewees choosing what to highlight and to detail. In fact, companies in the sample are very different between each other in terms, for example, of size, market, culture, organizational structure. It was therefore necessary to do not propose a too fixed pattern, but, instead, one allowing all differences to emerge. Of course,

especially in later case studies, the interviewer was aware of companies' peculiarities and was therefore able to pose more meaningful detailed questions during and at the end of the case studies. In fact, during all steps, if important information were given but not deepened enough, immediately or at the end of the interview the author has always asked further explanations. Results are therefore interviews able to catch every companies' peculiarities thanks to the freedom granted to the interviewees and to research unstructured nature, but at the same time standardized and comparable thanks to the BPA framework always present during case studies development.

5. BUSINESS PERFORMANCE ANALYTICS FRAMEWORK

In the Framework chapter, it is firstly given an overview of its structure and scope. Then, each primary and secondary block is detailed, adequately supported from literature. Lastly, it is illustrated the final result.

5.1 Introduction

The purpose of this framework is to give a complete and broad view of BPA, from how it is composed in its key components to how and which benefits it brings to companies, including how they are generated from improvements in Finance department activities. This comprehensive and structured perspective is missing in literature. It is built summarizing existing literature and validated with the support of experts in the field. A final validation is given in the following chapters through case studies.

It has been conceived as composed by four primary blocks:

1) *Business Performance Analytics (BPA)*;
2) *Improvement Areas*;
3) *Controllers Activities*;
4) *Company Benefits*.

Each of the four primary blocks, showed in *Figure 4-1*, is constituted by several secondary blocks, that are explained one by one. From the framework overview illustrated in *Figure 4-1*, it is possible to understand its purpose. A correct implementation of *BPA* brings punctual *Improvement Areas* to *Controller Activities*. Therefore, the company can enjoy several benefits, directly and indirectly related to Finance.

Research questions, formulated according to BPA framework structure, are:

- Analyze the *BPA* block to understand how its components are configurated in a specific scenario;
- Analyze how *Controller Activities* are impacted from punctual *Improvement Areas* enabled by *BPA* implementation;
- Analyze how *BPA* and its *Improvement Areas* of *Controllers Activities* can generate *Company Benefits*.

5.2 Business Performance Analytics (BPA)

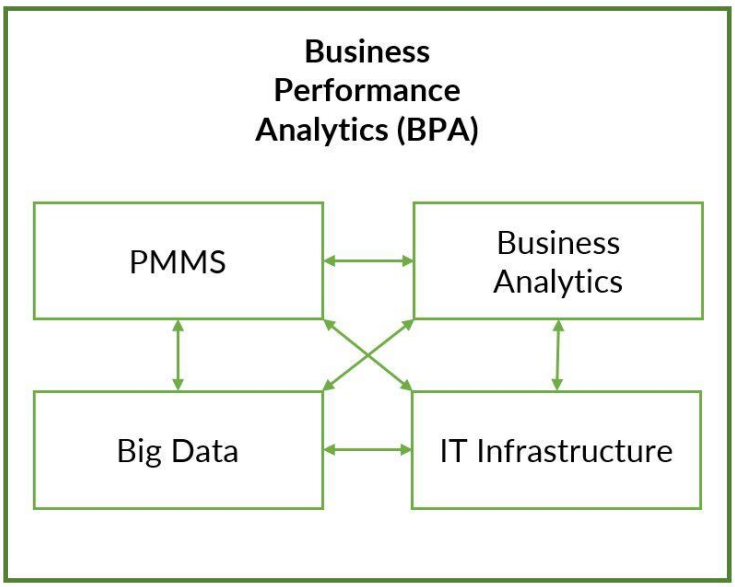


Figure 5-1, BPA block

The first primary block to be introduced is the core of the research, being the BPA system itself (Silvi & Visani, 2016). Its components have already been introduced in the Literature Review, and in the framework the follow the same scheme. They are all necessary for the company to receive the potential benefits, and complex relationships are present among them, as shown in *Figure 5-1*. In the following chapters, they will be described focusing more on these relationships, since in the Literature Review are already present punctual and detailed descriptions of each of them.

5.2.1 Performance Measurement and Management Systems (PMMS)

Performance Measurement and Management Systems and their characteristics have been analyzed in the dedicated chapter of the Literature Review. Following the APM model from Nielsen (2017) illustrated in *Figure 3-1*, they can be considered as a collection of accounting models. For the purpose of the research, they will be considered as classified according to Silvi & Visani (2016) perspective:

- *Strategic visibility systems* such as Balance Scorecards, Strategy Maps, Business Model Canvas, Tableau de Bord, Performance Prism;
- *Directional Control systems* such as budgets, flash reports, variance analyses;

- *Results analysis analytical tools*, such as suppliers Total Cost of Ownership, product target costing, life cycle costing, Activity Based Costing (ABC), process maps, customer equity.

PMMS are fundamental because, basically, they are what all BPA are implemented on, what BPA allows to empower. They represent the model in which Big Data must be collocated, after being manipulated with the right Business Analytics methods, everything enabled buy an adequate IT infrastructure.

5.2.2 **Business Analytics**

Business Analytics is another topic about which it has been developed a chapter in the Literature Review, described in terms of descriptive, predictive and prescriptive analytics, accordingly with the Orientation taxonomy proposed by Holsapple (2014). Here it is important to highlight their role as methods and techniques able to extract value from Big Data. Requirements of Business Analytics are given by PMMS and are enabled by IT infrastructure and technologies.

5.2.3 **Big Data**

Big Data is the paradigm unlocking a new and unexplored potential, to exploit which have been developed dedicated Business Analytics and IT infrastructures. In fact, Volume, Variety and Velocity of Big Data cannot be handled by traditional techniques and technologies. They allow to measure and monitor novel non-financial indicators, and to increase accuracy of the already existing ones.

5.2.4 **IT Infrastructure**

The IT infrastructure enables the BPA system. It must be:

- Customized, so that it can support adequate Accounting Models, as company's strategy requires;
- Advanced, so that it can support necessary Business Analytics and Big Data analytics techniques.

New technologies and software, overcoming the previous notion of RDBMS and able to handle Big Data and advanced Business Analytics, have been introduced in the Literature Review chapter. But technology itself is not enough, it must be shaped so that all Finance

processes, such as Performance Measurement and Management or Planning & Control, are supported in line with company strategy. According to S. L., company investments in IT infrastructure are focusing on the unification of the several company silos databases in unique and comprehensive data lakes, to improve their Veracity and Value characteristics.

5.3 Improvement Areas

In this primary block, there are several secondary ones describing what punctual improvements can BPA and its components bring to Finance function activities. They are shown in *Figure 5-2*. The meaning of this block makes more sense after the explanation of the next one, regarding *Controller Activities*, because of the interdependences between the two of them.

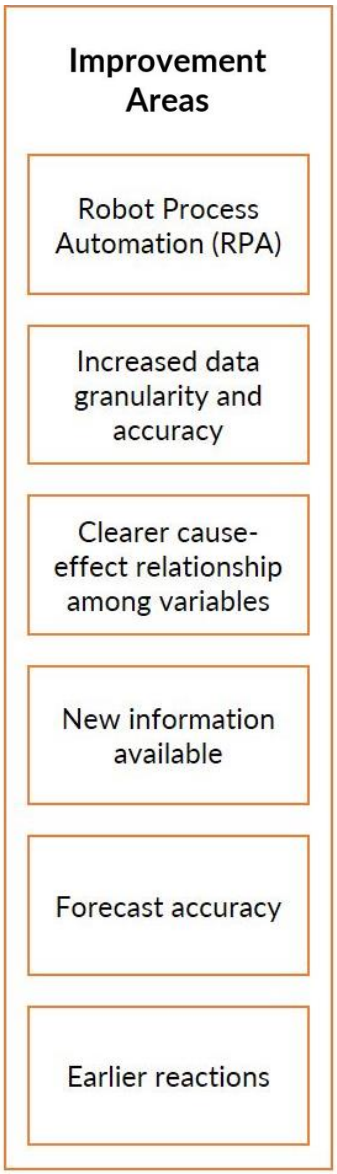


Figure 5-2, Improvement Areas block

5.3.1 Robot Process Automation (RPA)

The first improvement is *Robot Process Automation (RPA)*, referring to the introduction of software and algorithms that can substitute activities before from human controllers (Accenture, 2018; Gary Cokins, 2014; Plaschke et al., 2018). G. C. as well emphasized the relevance of this trend, quoting novel robotics technologies, for which there is already a market (Ernst & Young, 2016), applied to accounting that can relieve humans from performing repetitive activities. The President of Assocontroller highlighted that these innovations will free a considerable share of controllers' day time, and that therefore less workforce will be necessary in Finance department. To still be able to add value to the company, they need to improve their skillset, adding data analytics, and their attitude, switching to a digital mindset. These words from G. C. reaffirm the necessity of a considerable change of role requested to accountants in BPA revolution (T. H. . Davenport & Patil, 2012; McAfee & Brynjolfsson, 2012; McKinney et al., 2017). E. R. shares this point of view, highlighting the existence of Artificial Intelligence (AI) and

machine learning tools automating consistency checks of financial statements and also activities such as fraud detection. S. L. adds that recently are appearing on the market also artificial assistants able to execute with vocal input data analysis and reports. Automation has the potential of reshape entirely Finance function, considering that 42% of the activities can be fully automated and 19% more can be mostly automated (Plaschke et al., 2018). This allows to reduce costs and improve productivity, and let employees use their creativity to drive value and profits (Accenture, 2018).

5.3.2 Increased data granularity and accuracy

Data granularity is increasing thanks to Big Data, allowing to collect and analyze more detailed data than before (Chang et al., 2014; Manyika et al., 2011). Transactions at customers level are now available to companies (Manyika et al., 2011). Granularity can be evaluated and categorized in a data-type spectrum, composed by (Chang et al., 2014):

- *Micro-data*, the least aggregated level of data, that can refer to single individuals, for example one post on social networks, clickstreams in an internet session tracking for an user, etc.;
- *Meso-data*, the mid-level of data aggregation in very large data sets. An example is the analysis of the interaction of a group of users on social network, that can be a post together with its comments on Facebook, or a series of tweets and re-tweets on Twitter;
- *Macro-data*, the most aggregated data-type in large data sets, that can describe a market or a geographical area.

G. Co. suggested that increased granularity is strictly related to increased data accuracy, because it enables better consistency checks. For this reason, it has been added in the same secondary block.

5.3.3 Clearer cause-effect relationship between variables

New analytics, especially prescriptive analytics, allow to investigate further relationships among variables, and therefore answer a wide range of questions. No more only “What?” questions, such as “What do things cost?”, but also “So what?” and “Then what?” questions, allowing to deepen the understanding of cause-effect relationships and therefore involving what-if scenario planning and scenario analysis (Gary Cokins, 2014). Data mining and machine learning techniques can unveil relationships before unknown or increase the detail of others already known (Gary Cokins, 2014; Network Digital 360,

2017). Important relationships that can be made more clear thanks to analytics are those between KPIs in dashboards and strategic goals (G Cokins, 2013b; Gary Cokins, 2014). Intel, for example, managed to understand in detail the impact of its marketing investments on P&L (Nichols, 2014).

5.3.4 New information available

Big Data paradigm makes new data sources available to companies. However, data sources themselves are not that recent: the real innovation are analytics able to extract new information and therefore value from them (Gandomi & Haider, 2015). Organizations have been hoarding unstructured data from internal sources (e.g., sensor data) and external sources (e.g., social media). For instance, innovative facial recognition technologies empower brick-and-mortar retailers to acquire intelligence about store traffic, the age or gender composition of their customers, and their in-store movement patterns. This invaluable information is leveraged in decisions related to product promotions, placement, and staffing (Gandomi & Haider, 2015). Data from Enterprise Resource Planning (ERP) systems, Customers Relationship Management (CRM) programs, general ledger packages, weblogs, social media, e-mail, sensors, photographs, are other internal systems that can be made available for data mining; in addition, there is the data that is available in the public space such as forums and social networks (Fanning & Grant, 2013). New data and new analytics give Finance department new opportunities to improve PMMSs and implementing comprehensive monitoring and controls systems, for example to understand employees' moral performing text analytics on their emails (Rezaee & Wong, 2017).

5.3.5 Forecast Accuracy

Improvement of *Forecast Accuracy* is dependent from previous impact factor, in particular *Increased data granularity and accuracy*, *Clearer cause-effects relationship among variables* and *New information available*. Advanced analytics allow to forecast an incredible variety of phenomenon with a much higher accuracy level: weather conditions to improve the "on time" performance of an airline company (Barton & Court, 2012), sales performance of a new item (Visani et al., 2016), airline tickets prices (Min Chen et al., 2014), workforce needs for large industrial companies reflecting local market variations and workforce availability (Barton & Court, 2012), the number of people who will be diagnosed with a specific disease (Manyika et al., 2011). Another example less

directly business-related is Superstorm Sandy, whose wayward path has been forecasted with innovative analytics and Big Data in November 2012 (Fanning & Grant, 2013). Forecasts are improved also because it is possible to run simulations, thanks to prescriptive analytics, and provide a wide range of them depending on the value of certain chosen variables (G Cokins, 2013b; Manyika et al., 2011). In *Figure 5-3*, from Cokins, 2013b, it is possible to understand clearly the difference and what kind of advantage a decision maker can get.

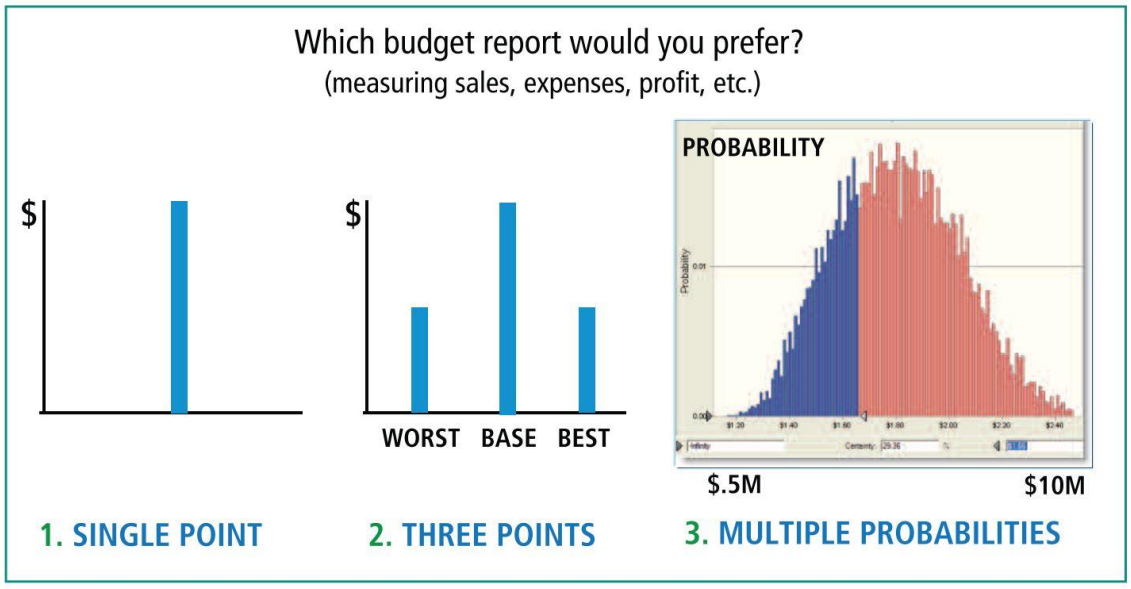


Figure 5-3, Analytics Probabilistic Planning Scenarios, from Cokins, 2013b

5.3.6 **Earlier Reactions**

Too often managers do not know the overview of undertaken actions and their effectiveness, because old PMMSs are structured to manage and represent phenomenon through financial and economic metrics, therefore lagging indicators that describe what has already happened (Network Digital 360, 2017). Innovative PMMSs implement advanced analytics and Big Data to provide information about events before they happen, and dashboards updated real-time about performances of on-going processes (Network Digital 360, 2017). Studies following implementation of structured reporting systems show that they let make managers trusting more data, and change their management style from reactive to proactive (Bititci et al., 2002). In fact, trust is recognized to be an important factor in managers reactive style (Manyika et al., 2011; Network Digital 360, 2017). Only 33% of CEO, according to interviews conducted from KPMG consulting,

has an high degree of trust in the accuracy of data and data analytics they have available (Network Digital 360, 2017).

5.4 Controller Activities

This block, illustrated in *Figure 5-4*, categorizes activities of the Finance function as *Controller Activities*. *Improvement Areas* described in the previous block will be linked to these activities, to explain how BPA represents a revolution for this function. More classifications are possible. This one has been adapted from one chosen because of its previous employment with similar purpose (Accenture, 2018). It must be said that impact on controller activities can be direct, but more often it will be indirect. This has been pointed out both from E. R. and S. L. The impact will be direct when data are of critical importance for the company, that therefore will implement proprietary and complex BPA systems. In other situations, external providers will be most likely asked to provide these analysis as a service, and only secondary tasks will be performed by the Finance function. The impact on the activity may be indirect also because analytics may improve directly other activities, and only then bringing advantages to *Controller Activities*. For example, more accurate sales forecast will increase also budget accuracy; predictive maintenance allows to improve accuracy of CAPEX and maintenance cost prediction. These activities, anyway, are not directly managed by Finance. The activities will be now briefly described one by one since, even if simple and common terms are used, they are generic and could therefore be misleading.

Figure 5-4, Controller Activities block

5.4.1 **Plan**

Plan, as defined by Accenture (2018), includes a wide range of activities, that have strategy as direct input. In fact, it includes:

- Strategic planning;
- Target setting;
- Financial planning;
- Forecasting;
- Tax/treasury planning.

Some of these secondary activities could be decomposed again. For example, competitive intelligence is an important activity involving analytics, but that in this case is included in strategic planning. Another activity, mentioned by E. R., is what he named Strategic modelling. It consists in breaking down overall indicators of company performances, for example EBITDA and EVA, to more punctual ones step by step. The result is a set of punctual indicators on which it is possible to act directly at an operational level, but that have an important effect on overall company performances. These punctual activities are explicated during the paper when necessary, for example if their importance is especially high in one case study.

5.4.2 **Administration**

Plan activities have usually a high strategic relevance. On the other hand, Finance function has also to carry out operational activities, necessary to the company but often repetitive and low value adding. Firms, as showed also in case studies, often name Finance function AFC, that stands for Amministrazione, Finanza e Controllo (Administration, Finance and Control). *Administration* activities, therefore, represent the "A" in the acronym. In this secondary block has been grouped more activities originally present singularly in Accenture (2018), since that level of detail is not needed for the purpose of this study, especially because of their low strategic relevance. They are *Transact*, *Account*, *Control* and *Comply*.

Transact activities deal with payments and more in general, as the name itself suggests, transactions, towards company stakeholders. They can be suppliers, employees and customers. Cash management activity is also included in *Transact* activities, and it is the

corporate process of managing cash, as well as using it for short-term investing. Its importance is related to company's financial stability and solvency. They are therefore:

- Supplier payments;
- Employee payments;
- Customer receipts;
- Cash management.

The nature of *Account* activities is similar to those included in *Transact* category. They have a direct impact on the account balance of the company, and include the following main sub-categories:

- Transaction accounting;
- Asset accounting;
- Tax accounting.

In this list, *Control* activities are not considered as those part of the Planning & Control cycle, that are present under different names in other categories. In this case, they are a mix of tasks that are mainly operational. Error processing and Internal audit can also have strategic relevance in terms of continuous improvement, if the company decides so.

- Account close/consolidation;
- Account reconciliation;
- Error processing;
- Internal audit.

Comply activities are carried out by companies aiming to conform to a rule, such as a specification, policy, standard or law. They are mainly traditional activities, subjected to national and international standards. International Financial Reporting Standards (IFRS) and Generally Accepted Accounting Principles (GAAP) are examples of international standards for Statutory reporting.

- Statutory reporting;
- Tax filing;
- Statutory compliance;
- Policy compliance.

5.4.3 Report

Report activities aim to prepare mainly Financial and Management reports. Enterprise performance reporting is an integrated approach towards these two types of reporting, supported from software provided for example from Oracle, one of the leaders in the market. Financial reporting is usually external and include documents such as the profit and loss statement, balance sheet, cash flow statement. *Comply* activities will make sure that these documents respect international standards. Management reporting is more customized according to managers needs. Different management reports usually exist vertically and horizontally across the same company.

- Enterprise performance reporting;
- Financial reporting;
- Management reporting.

5.4.4 Analyze

Analytics are intrinsic in *Analyze* activities, that are therefore deeply involved in the revolution subject of this Master Thesis effort. The main categories of analysis regard the portfolio, usually aiming to balance between maximizing returns and minimizing risks; performance, aiming at understanding why KPIs' targets have been overcome or missed; finally, investments, evaluating profitability of possible investments applying methods such as the popular Net Present Value (NPV).

- Portfolio analysis;
- Performance analysis;
- Investment analysis.

5.4.5 Advise

Advise activities are last in the list, because they are complementary and supportive of many of the ones present in the previous categories.

- Business advisor;
- Strategy execution support;
- M&A support;
- Board of directors' engagement.

Business advisor is actually a role, usually present in small and mid sized companies to provide financial and strategic advice. Usually advices are required mainly regarding strategic activities, such as the execution of strategy itself, M&A and board engagement. The latter refers to efforts put in bring enthusiasm and engagement in the board of directors about company Finance function vision and mission.

5.5 Company Benefits

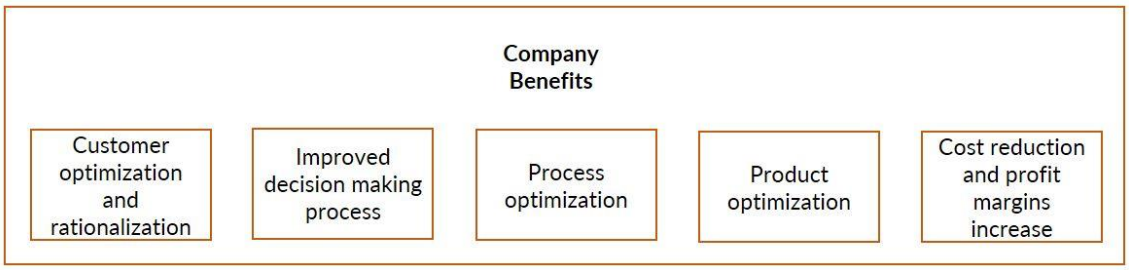


Figure 5-5, Company Benefits block

Company Benefits are those already included in the Literature Review chapter, plus *Customer optimization and rationalization*, added after interviewing G. Co. He argues that it is important to explicit the potential of BPA identifying the most profitable customers, and then take actions to increase their loyalty and retention. Another key characteristic of these benefits to highlight is that they are not only direct to the Finance function, but also indirect, and impacting overall company performances (Accenture, 2018). For details about each secondary benefit, it is possible to read the dedicated chapters in the Literature Review. A final consideration, however, is necessary: *Cost reduction and profit margins increase*, in fact, may be redundant, since it is the ultimate goal and effect of other *Company Benefits*. It has been included explicitly so that if, when developing case studies, interviewees cannot recognize among other four secondary block any of the benefits they are seeking, certainly they will agree on the last one. Basically, it makes sure that there will always one link present to *Company Benefits* block.

5.6 **Result**

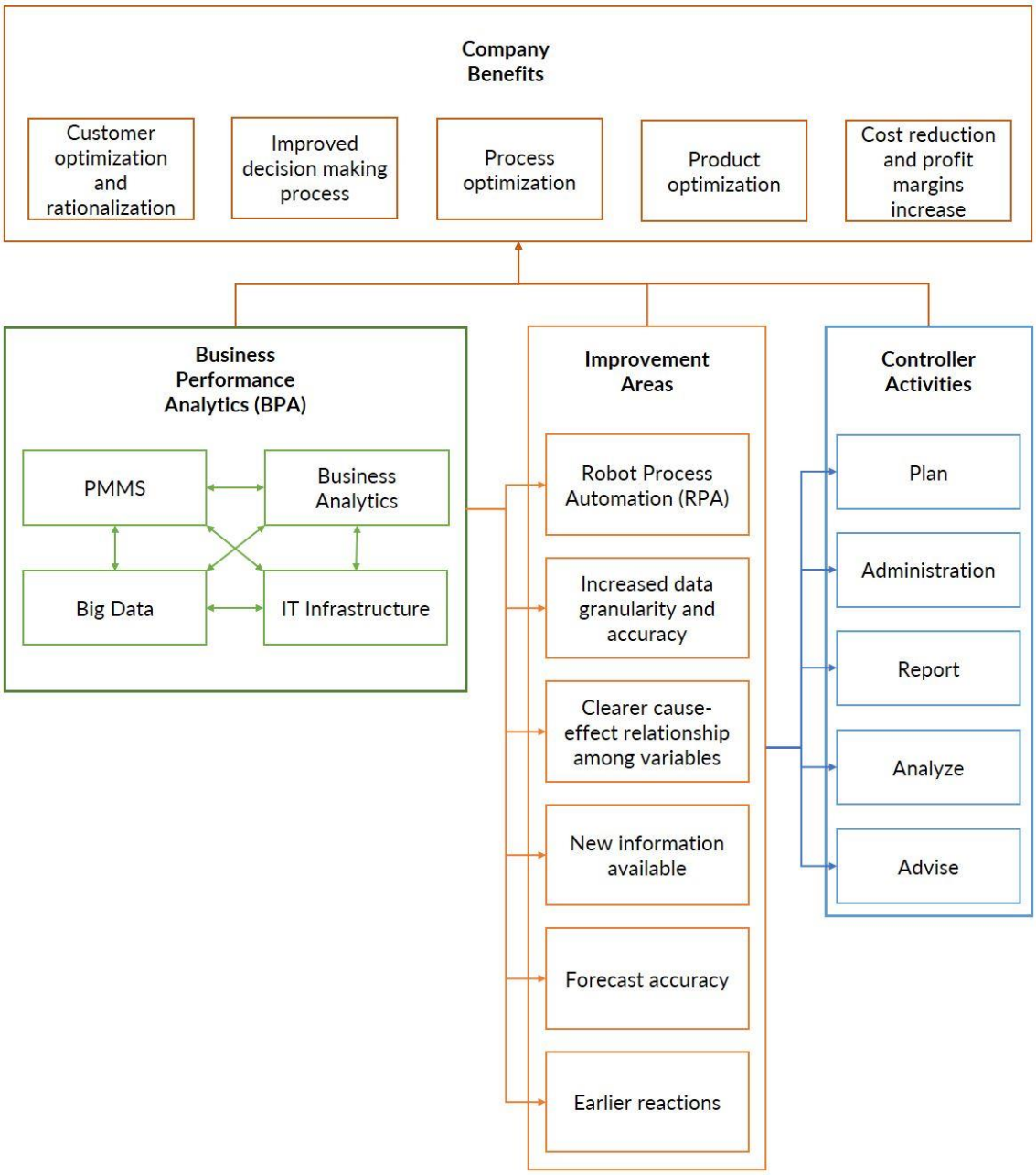


Figure 5-6, BPA framework

This how does the framework look like when all its components are linked, and secondary blocks included. Case studies will be the mean through which research goals explicated in *Figure 5-6* will be achieved.

6. CASE STUDIES

6.1 Introduction

Companies interviewed all asked to remain anonymous. Information about industry and size are provided in the introduction of each case study, together with a fake name.

It is important to highlight that not only big multinational companies have been studied. The sample includes also a Small-Medium Enterprise, whose development is critical in Italy but also in other economies. SMEs perspective is fundamental to understand the future of economies such as the Italian one. Many of them, as it happens for Glue S.p.A., one of the case studies presented below, compete internationally with multinational companies, that can invest much more on IT infrastructure and technologies, data analytics and BPA in general. This could lead to an erosion of SMEs competitive advantage: they need to quickly adapt and adopt these new technologies or will soon face the risk to succumb in an international competition every day fiercer than. They are therefore included in the case studies, together with companies of much bigger size in terms of employees and revenues. According to previous researches, only 7% of SMEs adopts Big Data Analytics (Osservatorio Big Data Analytics & Business Intelligence, 2017).

For each of them, general information is firstly provided; then, details of interviews are presented, focusing on peculiarities and aspects providing the greatest value to the research. The last paragraph of each case study is a summary of the findings with reference to the framework. It is also provided a customized version of the framework for each firm, describing current situation including projects already live. Most relevant blocks, in terms of priority or value added, are highlighted using a thicker box outline. The sequence in which they are presented is the same in which they have been interviewed.

6.2 Tools S.p.A.

6.2.1 Company overview

Industry	Mechanical Engineering
Revenues	135 M€
Employees	600

Table 6-1, Tools S.p.A. industry and dimension

Tools S.p.A. is a fake name for a manufacturing company based in North Italy and eight branches located worldwide. Dimensions can be quantified as around 600 employees and 135 million euros of revenues in 2017. In the Italian market, composed mainly (95%) by small companies with less than 10 employees (Confcommercio, 2009), it can be considered as a big company. Its competitive advantage stands not only in the high quality of its products, but also in brand strength and customers' loyalty. The company has been profitable during the years and in the near future no threat is visible. Anyway, the CEO believes much potential is still unexpressed residing in analytics and wants to exploit it in order to begin a new and steep growth. To do so, he is organising a new business unit, named Business Development & Digital Transformation, responsible of developing projects focused on digitalization and analytics that will then bring benefits to all other company functions.

The scenario in which the case study has been developed is firstly a lunch with the CEO and the Head of Business Development & Digital Transformation, during which projects guidelines and the underlining reasons have been explicated. Then, the researcher participated at a meeting with the Head of Business Development & Digital Transformation and consultants hired to support Tools S.p.A. deciding what steps to take.

6.2.2 Tools S.p.A. Business Performance Analytics

Tools S.p.A. is currently implementing only traditional BPA. In fact, predominant Business Analytics techniques are descriptive; data collected are structured, and their main source is company ERP system. External data about competitors are purchased and then internally analyzed. To study customers behavior, on the other hand, unstructured data analyses have been commissioned to external providers because of missing

competencies in the company. In terms of IT infrastructure, it is present a traditional unified data warehouse, following a relational logic and therefore not suited for storage of unstructured data.

Not all the projects Tools S.p.A. is developing are directly addressed towards Finance function, but it will be impacted by almost every of them.

Three main area constitute the main interests of the company, and they are:

- Competitive intelligence;
- Industrial;
- Marketing.

While competitive intelligence is part of strategic planning and therefore directly under Finance responsibility, other areas are not. Nevertheless, their impact on the function is relevant.

Competitive intelligence

Tools S.p.A. is interested in exploring new markets, that they think may be related to his own. The company does not know enough about these markets to enter them effectively. It is needed to develop analytics capabilities to explore these possibilities: for example, algorithms using keywords to find competitors in one specific market and then analyzing their online catalogs to extract products characteristics and prices. This technology is considered urgent from Tools S.p.A., since some product families they have already developed do not bring as much profit as planned, because of a wrong identification of the target market, as for example the stainless-steel tools product line:

<<*We strongly believe in the potential of our stainless-steel tools product line, but sales are not matching expectations. We went to a fair of machineries for the food and beverage industry and found out that the have the need of this kind of tools, since they can be cleaned and sanitized using strong acids. We want to uncover this information easily and believe analytics can help us.*>> Tools S.p.A. Head of Business Development & Digital Transformation.

Other products family they are worried may have the same issues are already in the designing phase. Employees with economic and analytic background are being hired to support this new process. Competitive intelligence is needed from the company to

improve another kind of process, that is pricing. Every year the company revise its price list, but the CEO is unhappy with the criteria used, considered too simplistic. He wants the process to become more analytic and using a greater variety of data, coming not only from inside the company, like for example historical data, but also external data coming from competitors and customers.

Referring to the framework, Tools S.p.A, implementing analytic competitive intelligence, is looking to increase the effectiveness of its *Plan* but also *Advise* activities, bringing as main improvement areas *Increased data granularity and accuracy*, *Clearer cause-effect relationship among variables*, *New information available*. These improvements aim to achieve, as company benefits, *Customer optimization and rationalization*, *Improved decision-making process* and *Cost reduction and profit margins increase*.

Industrial

Industrial is not the main concern at the moment. It is also less directly related to Finance compared to Competitive intelligence. Anyway, relevant projects are under development. Process mining is going to be employed to analyze data coming from customer care process, that is believed to have much room for improvement in terms of efficiency. Finance owns data about costs generated from it and will therefore be involved in performance analysis. Improvements brought to this activity will therefore be embedded in the function and employable also in future similar tasks. Plans include Artificial Intelligence (AI) implementation, to program a chat-bot able to substitute humans supporting customers and also employees. Currently, predictive maintenance is secondary in terms of priority. Anyway, it is going to affect Finance indirectly, improving the accuracy of its forecasts.

Referring to the framework, Tools S.p.A. implementing analytics in Industrial area, is going to improve mainly its *Analyze* activities, in terms of *Clearer cause-effect relationship among variables*, *New information available* and *Forecast accuracy*. Overall company benefits that the company expects to achieve are *Cost reduction and profit margins increase* and *Process optimization*.

Marketing

Marketing area is interested in terms of customers profiling, both distributors and final customers. Looking at distributors, the first activity will be performing a gap analysis, to understand the difference in their performance and what are the reasons behind these differences. It will be necessary not only to analyze quantitative internal data, but also observation at distributors points of sales. Final customers on the other hand, will need fidelity card to be adequately analyzed. This kind of analysis needs then to be integrated with ethnographic studies. Finance will be influenced because of its ownership of data, and therefore involved in performance analysis.

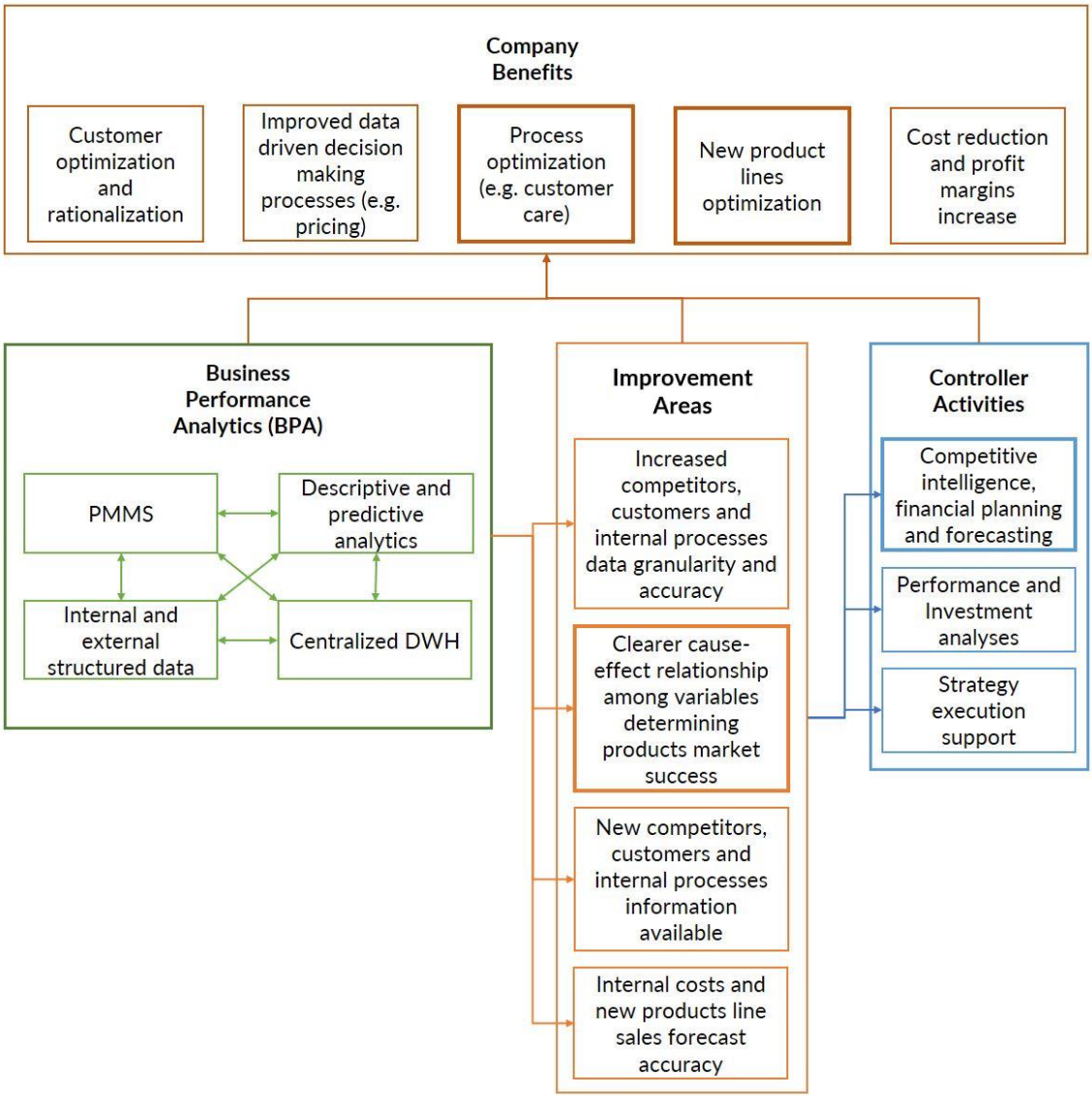


Figure 6-1, Tools S.p.A. Business Performance Analytics framework

Referring to the framework, Tools S.p.A. implementing analytics in Marketing area, is going to improve mainly *Analyze* activities, in terms of *Increased data granularity and accuracy*, *Clearer cause-effect relationship among variables* and *New information available*. Overall company benefits that the company expects to achieve are *Customer optimization and rationalization*, *Cost reduction and profit margins increase*.

Tools S.p.A. is a company that is still in the very early phase of BPA implementation. Anyway, top management strongly believes in its potential and necessity, planning investments and new hiring. Different backgrounds are looked for, ranging from engineering to data science, including also economics and management. Accommodations around the headquarters will be built to support new employees coming from all over the world moving in a new city. Finance function will be gradually involved, at first indirectly, then directly. It is believed that analytical background of controllers can be exploited pushing the project.

6.3 **Fintech S.p.A.**

6.3.1 **Company overview**

Industry	Financial Technology
Market cap.	1,7 B€
Employees	750

Table 6-2, Fintech S.p.A. industry and dimension

Fintech S.p.A. is one of the most valuable European start ups, based in the United Kingdom. Its market capitalization, better suited to measure start ups dimension rather than revenues, is close to 2 billion euros, and with less than three years of life, it has already around 3 million customers. Employees are instead around 750. It is a digital native company, and therefore data analytics is embedded in its culture. Their business is based on a mobile application on which users must register, entering their personal data. Payments, currency exchange and other operations are all effectuated through this app, giving therefore to Fintech S.p.A. easy access to related data, that can be analyzed for different purposes. Company culture is rooted in analytics: data analytics knowledge and analytical attitude are requirements for all associates.

The case study has been performed during a phone call with a Founder Associate based in London, who showed his personal use of BPA. Further applications are present in the company, but confidentiality of information becomes then too important, since there is where Fintech S.p.A. competitive advantage resides.

6.3.2 Fintech S.p.A. Business Performance Analytics

The main topic of the case study has been dashboards, related primarily with report and analyze controller activities. Each specific task has its own dashboard, indicating KPIs to monitor and improve. The Founder Associate is responsible of its own dashboard and has enough programming skills to manage it. He is therefore able to perform complex SQL queries to retrieve necessary data and create new indicators. Machine learning for predictive and prescriptive tasks is also in his skillset. One of his current goals is to redesign the KPI system for Compliance and Customer care business units, with an approach that will be in the future extended to all company.

The dashboard presented has been designed with the purpose of monitoring the customer care process, believed to be cause of inefficiencies and profit losses. It was noticed that the problem was being solved hiring new employees in the customer care center in East Europe, instead of actually improve performances. For this reason, top management asked to commit and focus on the issue.

Data used by Fintech S.p.A. in its BPA system are structured and internal. Many of them are coming from their mobile application. The IT infrastructure is therefore based on a traditional RDBMS, in particular Metabase, that is a provider of open source Business Intelligence servers. It allows basic and advanced data queries and manipulation. The effectiveness of analytics heavily relies on employees' skills.

The dashboard presents firstly a graph showing three main indicators and their evolution during time: open alerts, solved alerts and the backlog of cumulative alerts. These indicators have to be monitored; the controller aims at not having alerts at all, but when this happens the alerts must all be solved in a short time window. To better understand these performances, other considered data are the number of alert solved from each employee and their efficiency in terms of how many alerts are solved on the total arising each day. The interviewee can also access to the profile of each employee and see who is solving most alerts and can also use SQL queries to analyze further performances if he

believes it is necessary. In fact, he can track every single operation performed by employees on their workstation:

<<*Just today a new team started his job, they are going to reply banks reporting frauds. We are centralizing this activity, that was extremely inefficient. In this way, we can also better monitoring performances: in a first period data will be collected to analyze their job click by click, then we will set service level challenging and granular targets consistently with workload trends*>> Fintech S.p.A. Founder Associate.

This is especially useful in this moment, when the alerts ratio solved per employee needs to be improved, for example dismissing the least efficient operators. These analytics make the decision-making process faster and more accurate. Nevertheless, Further and punctual analysis to make sure the best decision is taken will be performed.

Of course, Fintech S.p.A. performs much more complex Business Analytics for other purposes only indirectly impacting firm's Finance function and controllers' activities. For example, predictive analytics, in particular proprietary machine learning models based mainly on the Random Forest algorithm, are developed to understand when their mobile app is used to do money laundering, or when frauds are perpetrated. Each transaction, in fact, is characterized by certain variables, simplest of which can be date and time, place. These models identify values of these variables that are similar in each type of illegal transaction. An alert is immediately delivered to responsible employees when this happens; then, further checks are conducted to confirm if the operation is really illegal or not.

Referring to the framework, it has been described how Fintech S.p.A. implements in his PMMS, and in particular dashboards, Business Analytics and using which IT structure. Improvements achieved are *Clearer cause-effect relationship among variables*, *Forecast accuracy* and *Earlier reactions*. Activities impacted are *Report* and *Analyze*. Overall company benefits sought are *Improved decision-making process*, *Process optimization* and *Cost reduction and profit margins increase*.

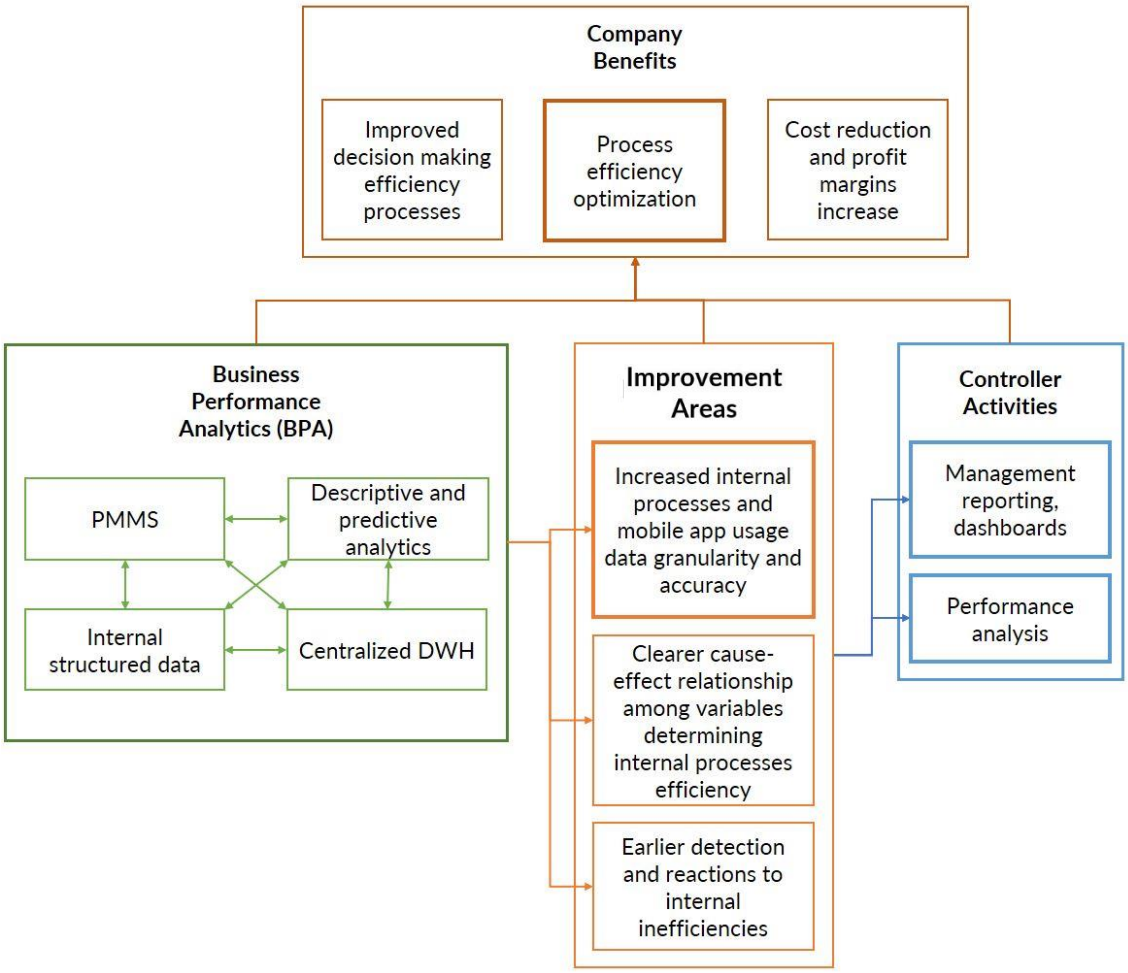


Figure 6-2, Fintech S.p.A. Business Performance Analytics framework

6.4 Glue S.p.A.

6.4.1 Company overview

Industry	Process Manufacturing
Revenues	35 M€
Employees	100

Table 6-3, Glue S.p.A. industry and dimension

Glue S.p.A. is part of the most important companies' category in Italy, the Small-Medium Enterprises. In fact, it counts around 100 employees and around 35 million euros of turnover. This leads to expectations of a lower degree of BPA implementation, and most

likely also less projects starting soon. Still, as mentioned in the introduction, also this study is important, since this companies' category constitutes the Italian industrial textile.

Glue S.p.A. core production is constituted by adhesive films. In the Italian market, the studied firm is well-positioned, also considering the competition of giants such as 3M and Avery Dennison. They are present also around Europe and in China through centralized distributors. In Italy, on the other hand, they sell directly to the small customers around the country through a dense network of agents. The close connection with their customers all along Italian territory is what constitutes their competitive advantage, allowing them to intercept any new special need but also to increase their loyalty. For the same purpose, workshops and other events are periodically organized in the company headquarters.

The interviewee is company CFO, who explained current situation and future plans. She also the software used in Finance function and its main functionalities.

6.4.2 Glue S.p.A. Business Performance Analytics

Business Performance Analytics in Glue S.p.A. are as expected at a low level of development. Nevertheless, basic systems exist, as well as a perception of the need of implementing more advanced methods and technologies.

Controllers can handle data in the system through a customized software. IT technicians, in fact, added several lines of code in order to easily access more complex queries and functionalities. Data analyzed are internal and structured, organized in a traditional RDBMS. This system is organized in siloes, meaning that Finance function cannot access directly all data. For example, Human Resources and Research & Development functions have their own databases, and therefore other functions must ask them to extract data they need to perform analyses on them. Business Analytics are used mostly for descriptive purposes. Only Marketing & Sales function, in fact, will employ predictive analytics, even if simple and at general level, while prescriptions and other predictions are left to managers' intuition.

The software can serve multiple purposes. First of all, it is used to prepare financial statements. It is programmed so that with a few clicks, data are organized so that comply with IFRS standards. This saves a lot of time to controllers, that can dedicate their time to more complex analyses. The problem is, the CFO admits, the software is not supportive

performing them. Data need to be exported to Microsoft Excel, and then manually analyzed. Of course, Office suite is not suitable for complex analytics and data visualization, that is what is more needed from Glue S.p.A. CFO. When willing to analyze customers profitability, for example, it is possible to filter receipts depending on agents who provided the offer, country, batch, articles, customer, operator who submitted the receipt in the system, currency. The same can be done not only for the receipts, but also for offers, contracts and other documents. After this first filters have been applied, anyway, it is needed to export data to Excel. Same if the user wants to see corresponding production cost of a certain order or offer. A separated spreadsheet has been prepared with the cost of each product code, allocated following an ABC logic. Then, cost and revenues can be matched for further analysis. Same method is applied when analyzing cash flows and debts. One constraint is that, in many cases, data are organized in siloes: HR departments can access specific data about salaries and benefits details that controllers cannot see by themselves. The same happens for the R&D function.

A data visualization software was used in the past to quickly prepare dashboards for the top management. However, that software was soon abandoned because considered not useful. Glue S.p.A. is still looking for providers of this kind of service.

More complex BPA is perceived as an urgent need: it is found difficult to really understand how single costs contribute together to form the overall results:

<<We have spent several time to implement an ABC logic to monitor our costs performances. However, we still do not trust these results, especially for what concerns fixed costs allocation, and therefore we can never be 100% sure whether a certain product code is profitable or not, or where the greatest inefficiencies are. For sure, to implement an analytical accountability system is our priority>> Glue S.p.A. CFO.

Product codes are around 20.000, too many to be efficiently handled from the current system. A brand-new software is needed, that allows easy access to data and different perspectives of these data. When making decisions regarding pricing and make-or-buy, for example, the management feels not adequately supported from data. If it is chosen to buy, the production volume is reduced: how does this influence profitability of other products? Prices are instead often decided according to sales agents' perception of customers' willingness to pay. New systems are necessary to give analytical support to

these decisions and therefore maximize profits. Implementing analytical support would also mean to embed in the organization competencies, currently in sales agents' hands: when one of them decides to leave the company, it can be a relevant problem. Decisions can therefore be faster, avoiding some negotiation steps between sales and production. Accuracy would also be impacted.

Referring to the framework, Glue S.p.A. at the moment employs BPA to improve *Administration* activities, leading to overall *Cost reduction and profit margins increase*, *Process optimization*. More important, are recognized as important next steps *Increased data granularity and accuracy*, *Clearer cause-effect relationships among variables*, *New information available* to improve *Report* and *Analyze* activities, aiming to *Improve decision-making process* and again *Cost reduction and profit margins increase*.

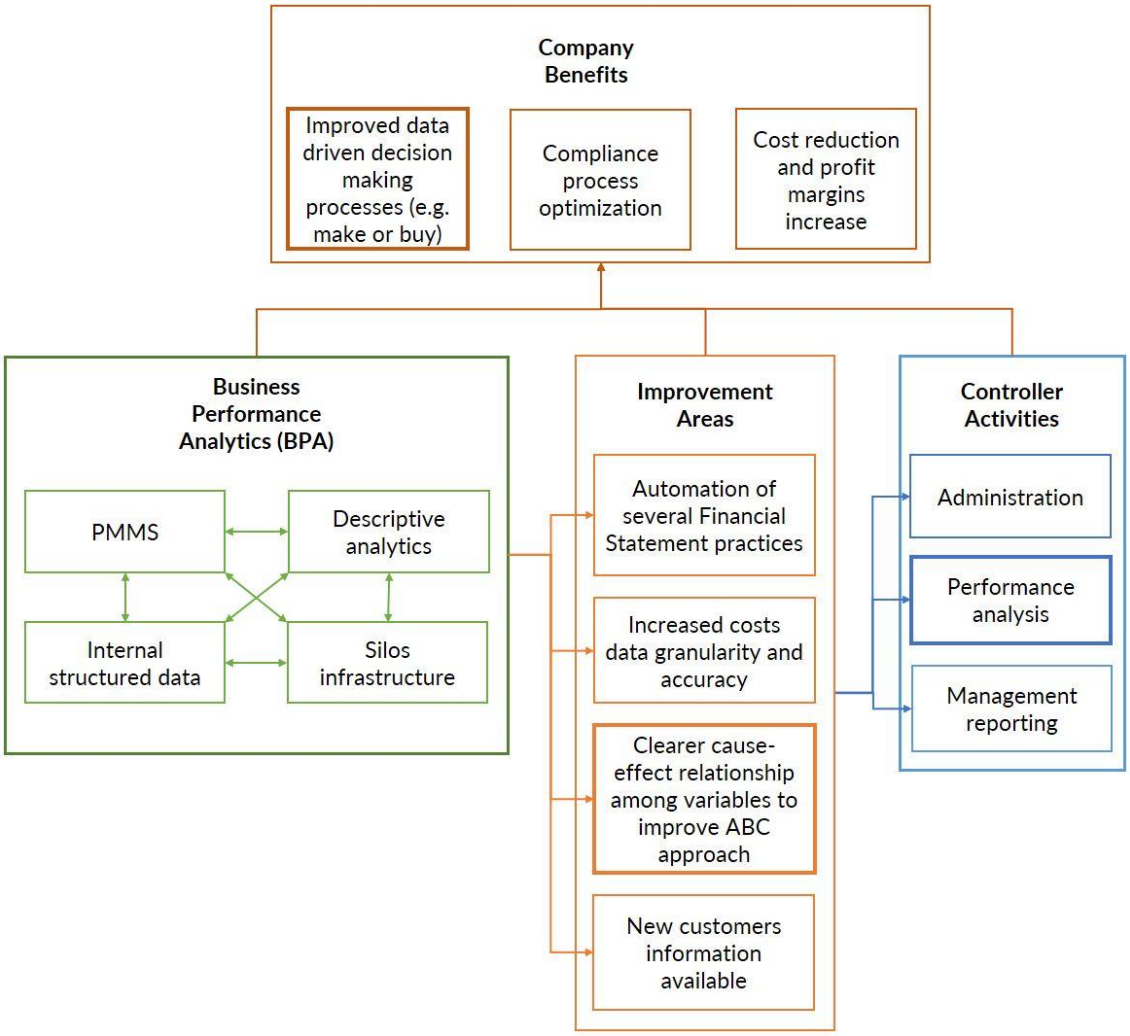


Figure 6-3, Glue S.p.A. Business Performance Analytics framework

6.5 Liquid S.p.A.

6.5.1 Company overview

Industry	Beverages
Revenues	1,8 B€
Employees	4020

Table 6-4, Liquid S.p.A. industry and dimension

Liquid S.p.A. is a big sized company, listed on the stock market. In 2017, in fact, it counted 4020 employees and a turnover of 1.8 billion €. It is an historical multinational Italian company, operating in the Food & Beverage industry. Company's competitive advantage does not reside only in the secret recipes of his beverages, but also in brand strength: emotions are sold together with drinks. Liquid S.p.A. is growing not only organically, but also through acquisition of smaller companies.

The Italian firm is looking to push growth further thanks to data analytics projects in all his functions, and Finance is one of those. An independent business unit has been created in order to kick off and manage them. The case study has been conducted interviewing a key member of this new entity. In this case, confidentiality was especially high since projects mentioned are still in their infancy and strategically fundamental. They have therefore been addressed from a general perspective.

6.5.2 Liquid S.p.A. Business Performance Analytics

Liquid S.p.A. considers Big data and data analytics as key to succeed in the market nowadays, and Finance function will be subjected to great changes. Investments are going in this direction, implementing software and enabling infrastructure able to support Big Data analytics, even if specific solutions have not been mentioned because of confidentiality reasons. Nevertheless, they see Strategic planning activities, such as competitive intelligence, as responsibility of other specific functions, and therefore Finance only indirectly impacted from this kind of activities. For these decisions and analyses, data scientists will be involved and responsible not only of understanding and manipulating data, but also of their visualization and communication to business users. From this point of view, their profile matches the one described from literature (T. H. .

Davenport & Patil, 2012). On the other hand, this means that Finance is not expected to "*ramp up as analytics leader*" and increase its relevance in the company (T. H. Davenport & Tay, 2016; Scoglio, 2018), or to become CEO's "Strategic advisor" (Gary Cokins, 2014), but on the contrary to have a role more operational than strategic in nature:

<<*To be honest, I do not really see Finance increasing its strategic relevance or analytic capabilities. We are implementing several projects following example from US companies. A dedicated business unit, composed mainly of Data Scientists is under development. They will have enough business comprehension to analytically support business users when taking decision, while Finance role, from a strategical point of view, will be marginal.*>> Liquid S.p.A. Digital Transformation Director.

Liquid S.p.A. has implemented a data lake to collect both structured and unstructured data, from internal and external sources. Nevertheless, only structured internal data are considered relevant for controllers' activities. Business Analytics implementation follows the same pattern: while considering the company as a whole not only descriptive, but also predictive and prescriptive analytics are widely employed, in Finance function the situation is different. There, only descriptive and predictive analytics are commonly performed. This is coherent with Liquid S.p.A. strategy, as presented in the previous paragraph: data scientists, exploiting BPA full potential, are working in other departments.

The main improvement is seen as automation, through Robot Process Automation. Simple and low value adding activities are going to be no more performed by humans, but by robots instead. Administration activities, such as Transact, involving for example the submission of invoices, now needs to be manually performed by employees and may be source of human mistakes. RPA will save time to controllers and avoid such mistakes. Report and Analysis activities will require less time to be performed, meaning that results will be achieved more easily, and more effort will be put on looking and understanding those results. Therefore, even if not as expected from previous research, empowerment of controllers is needed. The most important role will be the Business Controller who, thanks to an analytical attitude and a deep comprehension of the business, is able to use descriptive analytics to perform performance analysis and present results to business users. His/her responsibility, anyway, is limited to descriptive and partially to predictive

analytics: prescriptions are expected. These more complex analyses will be performed from data scientists, closer to Marketing & Sales function, for two main reasons:

- Liquid S.p.A. operates in a B2B market, and therefore data regarding final consumers are not directly available to Finance, but are obtained from Marketing & Sales through specific researches;
- Both a Marketing & Sales and analytical mindset are necessary to perform these analyses, and it is considered easier to bring the latter to the former rather than the opposite.

Business Controllers are expected to use descriptive analytics to achieve as improvement a clearer understanding of cause-effect relationship among variables. The interviewee provided the example of commodity prices variations, depending on which can be output a graph like the one presented in point 3 of *Figure 5-3*. To reduce risk, it is then possible to buy derivatives and other financial tools whose value is inversely related to the one of critical commodities. These models are based on statistical assumptions and are therefore not related to machine learning. Analyses of this type, anyway, are performed on data mainly internal and structured. Other type of decision they can support are cost reduction, make or buy.

Controllers will se their influence decrease in other typical Plan activities, such as budgeting. Data scientists are expected to propose a certain budget allocation, while Finance to bargain with the specific functions and gain their commitment. Report activities will follow the same trend. Only simple reports will still be input from business users to controllers. More sophisticated ones, involving complex and strategic decisions and deserving therefore advanced analytics techniques, will be performed from data scientists, who will provide on their initiative analyses comprehensive of suggested actions. Business users will add not quantifiable considerations (e.g. the loyalty of a point of sales to the company makes not possible aggressive policies) and take a decision.

The proactive arm of the organization is going to become Marketing & Sales, while Finance operations will dramatically improve their efficiency, but only slightly their strategic relevance.

Referring to the framework, Liquid S.p.A. employs, or is planning to employ, BPA to improve *Plan* and *Analyze* Controller Activities especially in terms of *Clearer cause-*

effect relationship among variables and *Forecast accuracy*, leading ultimately to *Improved decision making* and therefore *Cost reduction and profit margins increase*. Then, *Administration* Controller Activities through *Robot Process Automation (RPA)*, to achieve *Process optimization* and *Cost reduction and profit margins increase*.

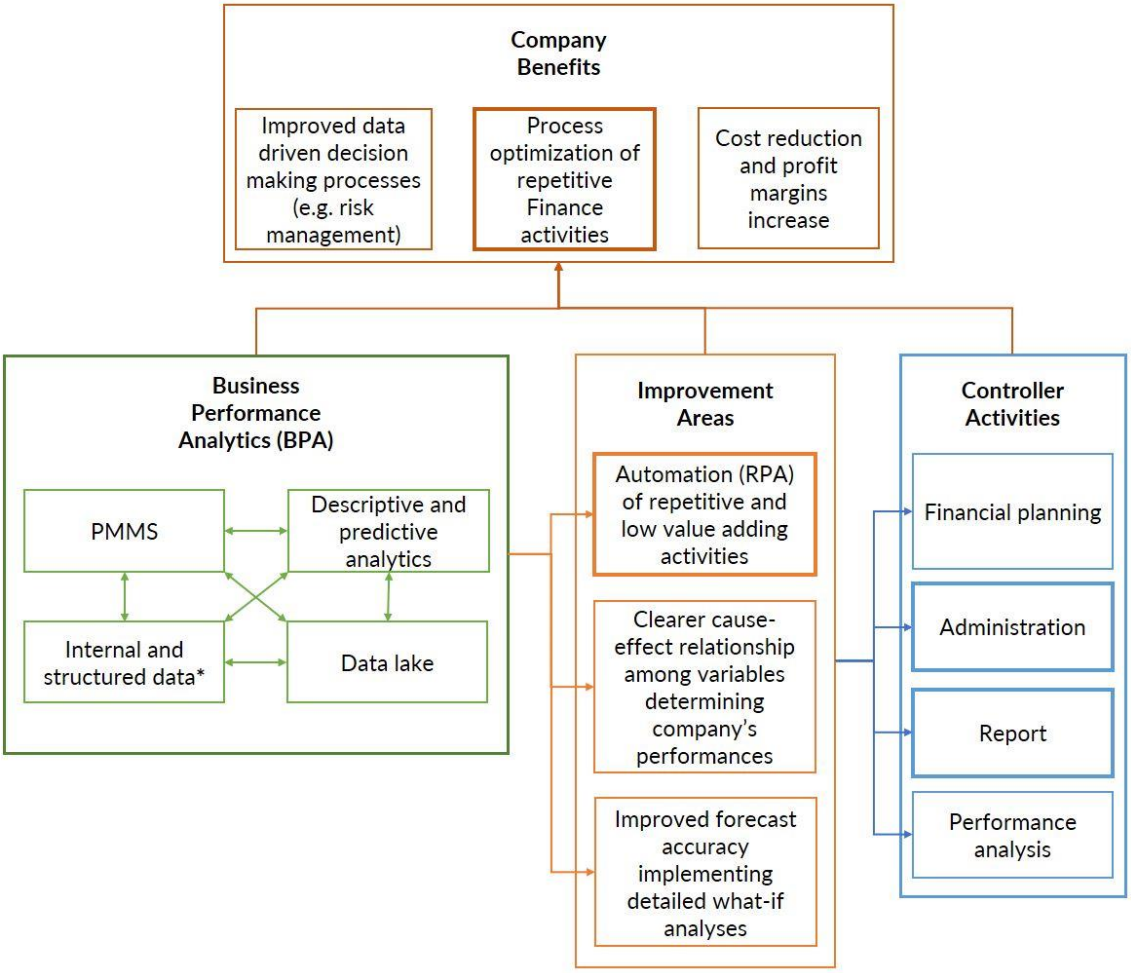


Figure 6-4, Liquid S.p.A. Business Performance Analytics framework

6.6 **Energy S.p.A.**

6.6.1 **Company overview**

Industry	Electricity, Natural gas
Revenues	74,7 B€
Employees	62000

Table 6-5, Energy S.p.A. industry and dimension

Energy S.p.A. is a big sized company, listed on the stocked market. In 2017, the turnover reached 74.7 billion euros; people employed were around 62000. It is the greatest company analyzed considering both indicators. Energy S.p.A. operates, of course in the market of energy, and its operations embrace production, distribution and sales of energy, plus additional services to final customers. Other factors contribute to increase complexity of the business, especially the worldwide presence of company branches and the existence of different businesses not only vertically on the supply chain as mentioned before, but also horizontally. In fact, renewables and fossil fuels markets have many differences and peculiarities and cannot therefore be considered in the same way.

Energy S.p.A. is heavily investing in Big Data and Business Analytics, strongly believing in the competitive advantage that these new technologies and methods can guarantee them. In fact, 126 collaborations with universities and research centers are on going, together with a network of 7 international innovation hubs. Finance is one of the main targets of this innovation wave, differently from what has been seen in other companies. The interviewees were two relevant people in the Administration, Finance & Control (AFC) function involved in the Digital Hub, a transversal entity in the company with the aim of driving digital transformation.

6.6.2 **Energy S.p.A. Business Performance Analytics**

Interviewees agreed that the presented framework well describes their view of analytics applications in Administration, Finance & Control (AFC), that is the name of what in this paper has been called Finance function. The company is still involved in building and improving an IT infrastructure able to store, organize and then analyse all necessary data, but is already harvesting benefits and has a clear view about the future. Energy S.p.A. is one of the few companies focusing a relevant share of analytics investments in AFC function and activities, and this is proved by the fact that no benchmark was found in the market.

In terms of technology, their main concern is now on the creation of a unified data lake, allowing users to access structured and unstructured data generated from every business line, and from external sources if necessary. The previous approach was traditional, considering functions as siloes, independent and with rare and difficult communication among them. Now, instead, every business line has still its own physical data lake, a

virtual one that links all of them has been created. This allows transversal analysis, aiming at discovering new relationships among variables before not known, or only grasped but not quantified.

<<Our efforts are now focusing on the update of our siloes IT infrastructure to a unified data lake, to enable cross business line analytics. Our business is incredibly complex and variegated: just think about energy production, distribution and sales. Each of them has its own peculiarities but are also clearly dependent on each other. We want now to uncover these relationships, neglected up to date.>> Energy S.p.A. AFC Digital Hub Chapter Leader Data Competence Center & Advanced Analytics.

This implies that both financial and non-financial data are collected and included in analyses. The company as a whole needs to deal with every type of data, structured and unstructured, but considering each business line independently, the balance between the two is different. For example, energy production involves almost only structured data, energy distribution a good balance between the two of them while sales a majority of unstructured data. The closer the business line gets to final customers, the greater is the percentage of unstructured data. Regarding AFC function, data needed are mainly structured, but unstructured data are key for analysis such as competitors Financial Statements for competitive intelligence and other benchmark purposes.

Data governance is perceived a key need and challenge implementing BPA. This is easily understandable considering Energy S.p.A. size and geographical extension, and also that recently many companies have been acquired. Each branch and subsidiary must collect and store data coherently, adopting the same policy. Standardization and industrialization of this process is on going, but many challenges are arising because of pre-existing differences. They must be overcome to achieve the final goal of a common data lake to perform transversal analyses on company data. One of the actions taken to reach this goal is SAP systems rationalization. In fact, because of several recent acquisitions, they reached a number of 20. In this moment, it has been reduced to 3.

The application of analytics is different in the two co-existing worlds of AFC function. In fact, in the Administration world, Robot Process Automation is the most widely improvement sought, the one that is believed to bring the greatest advantages. Energy S.p.A. is proud to be one of the pioneers in the application of these new technologies

implementing Artificial Intelligence, and it is also satisfied with the results achieved. In particular, Transact and Account activities brought great results in terms of savings. It is important to specify that it is not possible to completely exclude human beings from the process, and that periodically employees must check that the software is carrying out the job properly. Another activity traditionally performed by Administration in Energy S.p.A., and whose efficiency is going to be dramatically improved soon, is SAP system customization. It is important considering the several acquisitions conducted by the company in recent years, as already mentioned. Every company has its own SAP system, following it own logic of data collection and classification. Of course, this is an issue that constitutes a barrier for a transversal analysis of company data along all the business units. Energy S.p.A. goal, in this case, is to implement RPA so that it is enough to specify some peculiarities of the acquired company SAP system, and then this is automatically customized following holding one standards. This activity is significantly time-consuming right now, and therefore this project is expected to add relevant value to the company. Another possible use case, still not explored, regards the aforementioned data governance and in particular data quality. This is going to be achieved implementing machine learning algorithms understanding what common features of low quality data are and therefore being able to notice users when this kind of mistakes happen.

Considering the Finance & Control world of AFC, RPA is not the improvement expected to bring advantages the most. On the other hand, a better understanding of cause-effect relationship among variables, new information available and increased data granularity concur to improve Plan, Analyse and Advise activities. In this case, Energy S.p.A. main goal is to include Big Data from different sources to improve the accuracy and also the granularity of financial performances of each business unit, and therefore develop rolling budgets updating daily, and not monthly as it was done before. The analysis is therefore going to be performed on a Near Real Time frequency. Data that can now be included in Analyze activities include weather forecast, impacting renewable energies business line, exchange rates, fundamental in a multinational company quoted in different stock exchanges such as Energy S.p.A., or final customers comments on social networks, that can give hints on future sales trends. These improvements of course imply another one, that is the possibility to have important information before and therefore react earlier, more quickly. Comply and Control activities are impacted considering that before the

Financial Statements preparation was mostly manual. Every executive was bringing his/her own data, CFO included. Long no-value adding discussions often arose understanding who was right and who was not. Now, machine learning algorithms, including the already described variety of shared data, provide a basis from which starting the discussion that cannot be challenged. This makes the process not only more accurate, but also more fluid, transparent and, above all, efficient. Finally, Report activities will also see several improvements. Before, AFC function was becoming a reports production center, with every function asking to prepare a specific report. Now, Artificial Intelligence made possible to develop new, simpler, software, easier to use from everyone. The goal is therefore self-reporting, allowing every function to prepare its own report according to their requirements. This does not only free time to controllers that can therefore focus more on other Analyze activities adding more value, but also avoids possible conflicts between AFC and other functions.

Interviewees provided their view on the future role of Finance function. Is CFO destined to become CEO's "Strategic Advisor" (Gary Cokins, 2014)? This question allowed to compare the views of the two biggest companies in the sample. The view shared in this case matches that proposed by Cokins, 2014. The CFO is considered the only figure who, at the same time, has a full comprehension of the business and the necessary mindset to cover a role such as CEO's "Strategic Advisor". This is what it is expected to happen in Energy S.p.A. An alternative they believe is a good choice, from their experience, is the Chief Information Officer (CIO), that has similar characteristics in terms of business view and attitude to the CFO. Anyway, the latter is responsible for the Financial Statements published, since the company studied is listed on the stock exchange. For this reason, it is coherent that he can have full control on the process. They concluded saying that alternatives such as the Chief Marketing Officer may be adequate, but for simpler businesses, where the economic and financial impact is not so transversal to overall company performances.

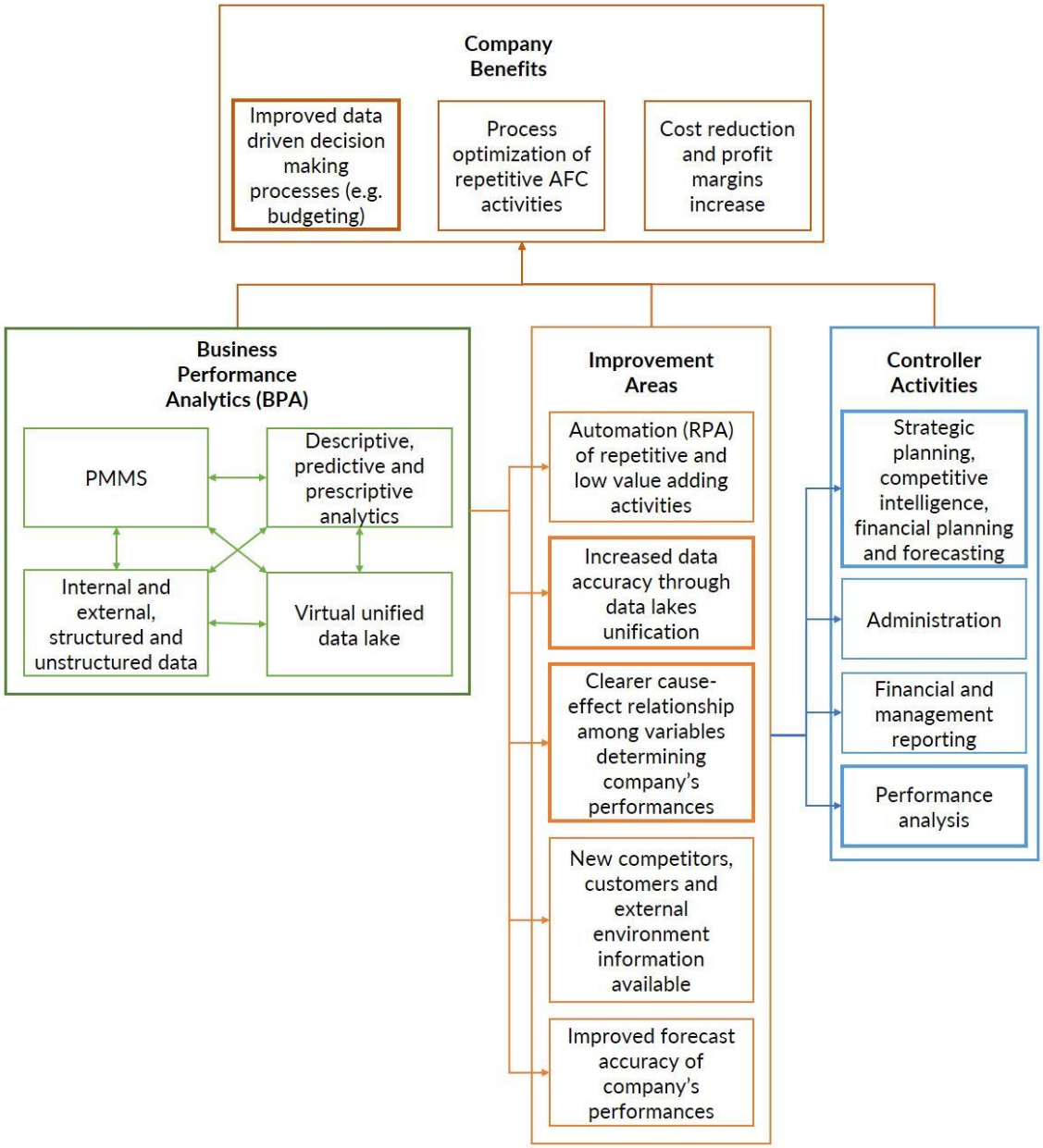


Figure 6-5, Energy S.p.A. Business Performance Analytics framework

Referring to the framework, Energy S.p.A. employs BPA to improve all *Plan*, *Transact*, *Account*, *Control*, *Comply*, *Report*, *Analyze* and *Advise* controllers activities. While the mostly operational ones in nature, above all *Transact* and *Account*, are mostly improved in terms of efficiency through *Robot Process Automation*, the others increased their efficacy thanks to *Increased data granularity and accuracy*, *Clearer cause-effect relationship among variables*, *New information available*, better *Forecast accuracy* and *Earlier reactions*. Regarding overall company benefits, the most important goals regard

Process optimization, *Improved decision-making process* and *Cost reduction and profit margins increase*.

6.7 Nice House S.p.A.

6.7.1 Company overview

Industry	Retail Trade
Revenues	306 M€
Employees	2500

Table 6-6, Nice House S.p.A. industry and dimension

Nice House S.p.A. is, according to official European definitions, of big size. In fact, it counts around 2500 employees, and in 2017 revenues reached a maximum of 306 million euros. Nevertheless, the numbers show that dimensions are much lower compared to Liquid S.p.A. and Energy S.p.A. Nice House S.p.A. is an intermediary in the selling of furniture and furnishings. It does not produce anything and sells mainly through franchising stores and secondarily through owned points of sale. Marketing and sales is therefore a key aspect in the business. The company experienced an incredible growth especially in the last ten years, thanks to many factors among which stands out the interception of customer needs, from expensive and customized furniture and furnishings to cheaper and standardized ones.

The interview has been conducted in the headquarters, and it has been divided in two parts. In the first part, three employees participated, belonging to Finance, E-commerce and Business Intelligence business units. In the second part, the CFO was interviewed singularly. The steep growth and internationalization experienced in the recent past from Nice House S.p.A. made the company realize the necessity of better structuring its processes, and therefore to shift to a more data-driven approach. This shift is still in its infancy, but significant improvements have been applied already.

6.7.2 Nice House S.p.A. Business Performance Analytics

Nice House S.p.A. has a dedicated business unit following the IT enabling infrastructure and software development, called Business Intelligence. The responsible of this business unit is satisfied about how they have implemented what he calls “Level 1.0”, but at the

same time he is aware that this is just the beginning and further steps are necessary. A central data warehouse collects all company data, coming from the ERP, HR database, store management database and others. It is a traditional relational database, and collects therefore only structured data, that are anyway both internal and external. Internal ones have a high detail level. Each customer order, for example, is broken down to the level of product lines, each one characterized in terms of department, cost center and expense, plus other depending on the item. Examples of external data are those about weather, or about customers behaviour using the website ("clickstream"). Currently, unstructured data are not collected, but plans exist to exploit social network resources. This is one of the reasons why the interviewee talks about "Level 1.0". The second one is that these data are analyzed only in descriptive terms, while predictions and prescriptions are still left in the hands of managers' intuition in most situations. Until now this worked out incredibly well for the company, as it is possible to see from their growth. Anyway, this growth, together with the opening of international stores all around Europe, Middle East and Asia, increased the level of complexity and now the necessity of a more data-driven approach is arising.

Working mainly as an intermediary, Nice House S.p.A. is focused on the commercial part, that is the one impacting business performances the most. Their focus is on being able to sell the products, while for other businesses such as Energy S.p.A., selling a commodity, this may be of secondary priority and mainly achieved through price wars. This is one of the reasons why many investments in analytics are put in the commercial sides of the company. Customers needs analysis is carried out by this company' section, and impacts only indirectly the AFC function, that can, thanks to these analyses, provide more granular and accurate forecasts. In particular, it has been recently launched, supported from external consultants, a project to develop a multi-channel strategy that includes the design of a unified Customers Relationship Management (CRM) system for all company points of sales. Data collected from each of them must be organized in a similar way, so that they can be analyzed together if necessary. Not all points of sale are monitored yet: physical stores data are not collected for example. For the future, the CFO foresees that Nice House S.p.A. will purchase external data from social networks or banks. In the case of banks, credit cards data may provide important information about the budget of different consumers categories. In general, datasets are going to be expanded adding all

data that may be useful. Another project that will indirectly impact AFC function activities is about promotions and advertising campaigns. They are great expenditures for the company and are often launched with short notice. This makes problematic for controllers to take care of cash flows that, especially for an intermediary company such as Nice House S.p.A., are of utterly importance. Better understanding their effects and in which situations they are more effective would help when planning this kind of actions, eventually simplifying, and also increasing the accuracy, of AFC job.

Other several projects, instead, have been thought precisely for improving controllers' activities, and have therefore a direct impact on them. The most important project has been conducted supported by Microsoft, implementing machine learning algorithms through Cortana software to perform what during preliminary interviews has been called Strategic modelling. In fact, a deep correlation analysis between numerous variables has been carried out, to understand which non-financial and detailed indicators impact overall company performances the most. Thanks to this project, that is still going on, AFC can now be more helpful and supportive when taking strategic decisions such as if to open or not a new store, and how should it be, or if to close or not an old one. For example, it has been found out that stores dimensions must be kept over a certain minimum threshold, and under another maximum one, or their launch will be unsuccessful. In the past, this missing information caused the failure of several stores and serious economic losses. The same can be said about demographical information, now always included in the analysis. In the past, a new store was open in the French Riviera, that looked like a convenient location because simple to serve from a logistic point of view:

<<At the time, we were joking saying that it would have been easier and cheaper to open a store in the French Riviera than in Sardinia. We were growing very fast and not concerned about stores performance and were very surprised about awful they were. However, we noticed very soon that the mistake was neglecting important socio-cultural variables, like family income or apartments surface.>> Nice House S.p.A. Finance Director.

Nevertheless, that is a richer area compared to average Italian territory, and has other peculiar characteristics that were not considered and caused store performances to be much lower than expected. Similar analyses were conducted to reduce some of the most

relevant company costs, that are personnel cost (most relevant one) and logistics costs. As regards the former, customers flow has been related to other variables such as day of the week and weather, to understand the optimum number of salespersons and cashiers to be present on a certain shift and day. As regards logistics, AFC function covered a key role in the analyses performed to understand how to minimize the number of warehouses and distribution centers, and eventually costs. They were more than 10 in Italy, but when the project will be concluded, only 2 will remain.

Another relevant output of the Cortana project is a brand-new Balance Scorecard system, based on a software named Reporting Services, provided by Microsoft. The development comprehended all phases, starting from the explication of company strategy, then strategic objectives divided according to the four BSC categories and to company area (store, corporate sales, stock, productivity), and finally KPI definition. In this phase of the projects, however, the relationship between strategic objectives and operational KPIs is still not quantified but decided through a focus group involving relevant managers. For each of these indicators, it is possible to visualize several characteristics with a simple click. The one that is considered to be most important is the quality of data used to compute them, that can be evaluate as A, B, C or D. In this way, managers consulting the dashboard know if they can fully trust what they are reading, or if further clarification is needed with the Chief Data Officer. He is also responsible of improving data quality, following priorities settled by top management. The output is a set of around 70 indicators, with possibility of further drill down each of them, a sub-set of which is visible to each function manager. The CFO and top management, on the other hand, can keep track of all of them. These data provide a unified view to all management, differently from what was happening before, when everyone has his/her own Excel sheets, organized following different logics. Excel is still used to develop more specific reports and analyses. The advantages recognized to the Office suite are those of flexibility and simplicity allowing self-service reporting, while on the other hand analytics and low graphic personalization are considered main limits. Another reporting software that has recently started to be employed is Power BI, that makes easier to notice relevant information thanks to better graphics. Moreover, it is implemented via Cloud and include a mobile application. However, advanced analytics are not available. To have three different dashboards software may cause confusion. Furthermore, as mention at the beginning of the case study,

analytics in this case are only of descriptive nature, and not predictive or prescriptive. Reporting is considered an activity high value adding, if correctly implemented. In fact, it helps in clarifying objectives to all readers, and therefore guide all further analyses and actions. To support reporting, Data visualization is considered another necessary skill, since it is recognized that choosing a graph instead of another can change the perception of the reader.

Competitive intelligence is another activity that is performed employing only basic descriptive statistical techniques, and that are recognized to need improvements and updates. Planning & Control cycle, and in particular budget, is another critical activity for AFC function. In fact, controllers often cannot make long term accurate forecast, because of significant expenditures that are not constant through the years. Examples are the already mentioned promotions and advertising campaigns. While descriptive analytics re well developed, a lack of prediction and prescription causes these difficulties.

Human resources are considered key to shift company culture and make it become data-driven. To this purpose, professionals with mathematical and engineering background have been hired, even if lacking any retail experience and background. These new employees immediately after their hiring are sent through every area of the business, to gain a complete comprehension of it. This is considered a requirement to then conduct any significant analytics project.

Referring to the framework, Nice House S.p.A. employs and sees future value of BPA in improving *Plan*, *Report* and *Analyze* activities, especially in terms of *Increased data granularity and accuracy*, *Clearer cause-effect among variables*, *New information available*, *Forecast accuracy*. In this case study, automation and therefore efficiency increase of operational and repetitive activities is considered of lower priority. As regards overall company benefits, main Nice House S.p.A. goals are *Cost reduction and profit margins increase*, *Improved decision-making process* and *Process optimization*.

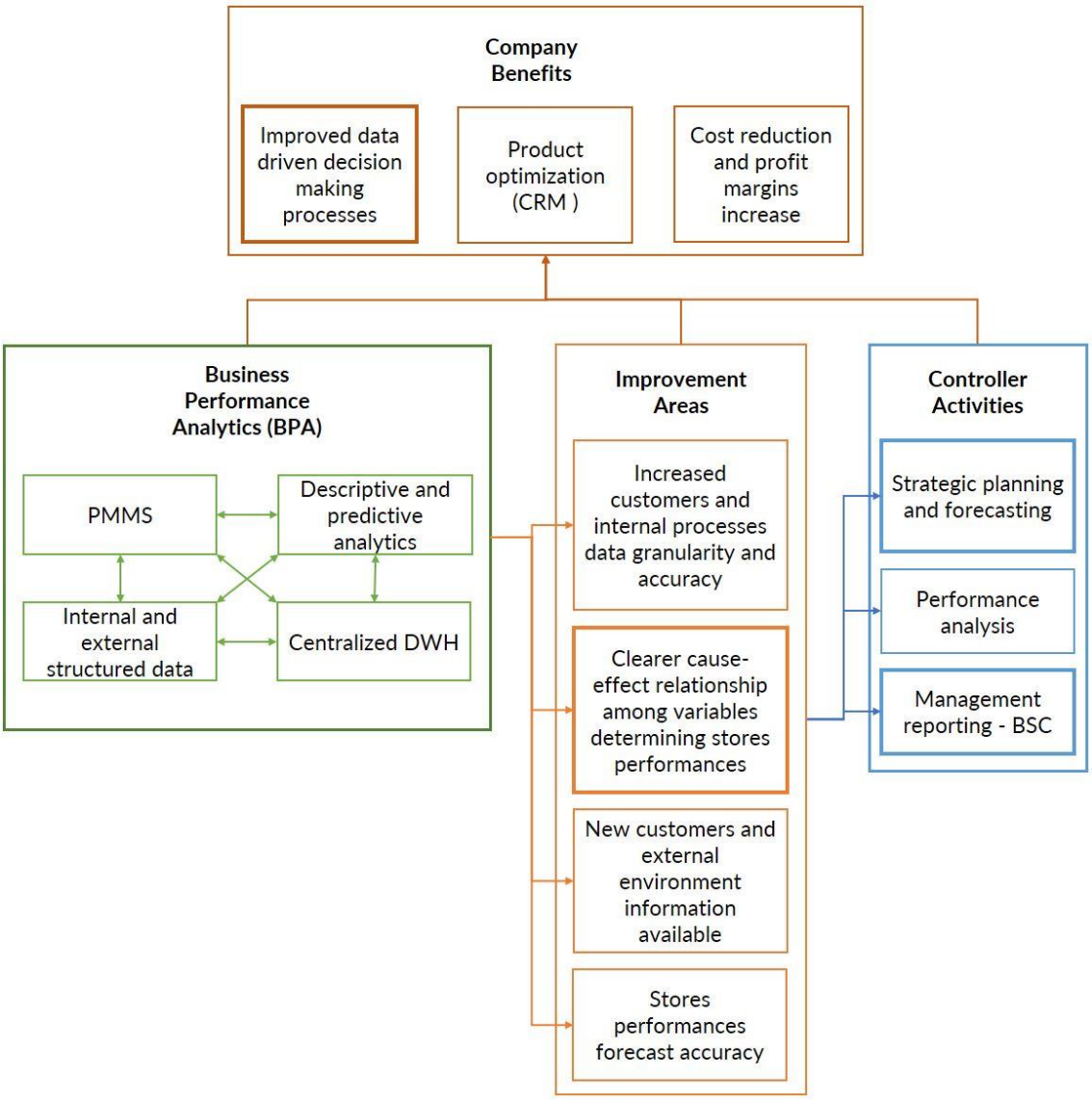


Figure 6-6, Nice House S.p.A. Business Performance Analytics framework

6.8 **Water S.p.A.**

6.8.1 **Company overview**

Industry	Water Supply
Revenues	100 M€
Employees	320

Table 6-7, Water S.p.A. industry and dimension

Water S.p.A. is a big sized company, since it counts around 320 employees, number greater than the threshold of 249 under which it would have been classified as Small-Medium Enterprise. Firm's turnover in 2017 reached 100 million euros, thanks to 160000 users. The peculiarity of this company, compared to the rest of the sample is that it is public, responsible for a specific territory in the North of Italy. In terms of industry, it has similarities with Energy S.p.A., since it operates in the utilities market. Water S.p.A., as the name suggests, works in the water utility business. In particular, there are three business lines: managing aqueducts, water purification and drainage systems. The three of them are obviously strictly related in terms of performances, since all the water brought to users through aqueducts must be purified and then drained. Another important characteristic of the case study, deeply influencing the firm, is the monopolistic nature of the industry. This let the company the opportunity to focus and invest on efficiency, while marketing activities become of least importance.

The case study has been developed interviewing Water S.p.A. CFO, who has a long experience in the field in big multinational companies. The interviewee showed awareness of new technologies and of their potential and necessity. Nevertheless, their impact, currently, is mainly indirect and doubts about future evolution in the firm persist.

6.8.2 **Water S.p.A. Business Performance Analytics**

Despite being a public and monopolistic firm, Water S.p.A. invests each year around one third of its revenues in several innovation projects. The core IT system, for example, has been fully renewed in 2017, implementing latest Oracle technologies. Now, a new Business Intelligence system project, supported by the same provider, is being developed to further empower the whole firm but primarily Finance function. In fact, controllers will be responsible of using these new tools to extract, transform and load data into servers. However, it will be based on a RDBMS allowing complex OLAP techniques and methods but not supporting efficient unstructured data management. In this moment, anyway, there is not any necessity of collecting or manipulating this format of data. In fact, the most common type of unstructured data needed by companies, as seen also in previous case studies, is related to customer behaviour and opinions, issues not key for Water S.p.A monopolistic business, and that probably will be considered only later in BPA development. Other IT systems exist in the company, communicating through dedicated

interfaces with the main Oracle one. For instance, another software, specific for companies operating in the utilities market and developed from an Italian company, has been implemented to manage commercial and sales data. Other siloes are dedicated to specific projects. It has been mentioned that the format analyzed is almost always structured; the source, on the other hand, it is not only internal, but several external sources are exploited as well. For Water S.p.A. it is especially interesting and useful to know well weather conditions, in terms for example of air and earth's temperature, or rainfalls.

A recent project in fact, on which several million euros have been invested, was kicked off to be able to measure accurately rainfalls in every area of the territory. More than 1000 rain gauges have been installed around the province, together with the necessary infrastructure. Rainfalls data are available since the 19th century, but this project aims to increase dramatically granularity and accuracy of these measurements. But what is the final goal? These data are linked with maps offered from the SIT (Sistema Informativo Territoriale, that means "territory IT system") describing territory morphology and those describing aqueducts, water purifiers and drainage systems infrastructures. In this way, it is possible, through dedicated software, to develop virtual models of the reality and conduct several what-if analyses, identifying where are the weak points of the infrastructure. It is Water S.p.A. responsibility, in fact, to avoid flooding whatever weather conditions may happen. Special tanks are built in the pipelines network in order to work as buffers when rainfalls level is too high. The system service level is controlled using a KPI called "return time", measured in years. The target in particular is 10 years, meaning that the system must be able to tolerate the greatest rainfall that may happen in 10 years, considering historical data. Other data collected about the territory are extracted from satellite pictures and describe earth's temperature. Depending on values, it is possible to identify possible spots in the pipelines network where water leakage happens. In fact, around 20% of the water collected from rivers and lakes is then lost and wasted. This initiative, in collaboration with Genova University and Epson, aims at improving water leakage performance. Analyses on internal data are simpler and focused on forecasting what will be the usage level in each period of the year. It is in fact known that in warm seasons much more water is consumed compared to cold ones, and Water S.p.A. system must be correctly dimensioned to manage demand peaks. This kind of data is

object of a project aiming to increase granularity and accuracy. New meters are being installed in consumers' house, that will allow on one side customers to autonomously read their consumption, and on the other the company to receive more data without sending technicians to every house. Moreover, these data describe customers behaviour during the day, while before it was possible to know only the overall amount consumed between technicians' visits. These new meters are also "intelligent", since once they have learnt customer consumption pattern, they are also able to intercept behaviour anomalies. Other intelligent performance measurement systems using analytics are installed on water pumps, that are 450 in total. They control the pressure in the system and other secondary parameters, so that when a problem in the system arise, it is possible to immediately understand in which point the original cause is. Before, technicians team had to investigate many possible spots before understanding where the issue was and what was precisely about. In this way, significant maintenance costs are saved.

Robot Process Automation is applied in some basic Administration processes, on the same pattern of previous case studies. Transact and Account activities are almost entirely automated: humans need only to confirm data and accept the output of robots' activities. Periodic reports are also automatically generated by the ERP system and report processes standardized and industrialized, avoiding manual data extraction, transformation and visualization as it was performed before. Specific reports are still prepared by skilled employees, able to write complex SQL queries and, more in general, to manipulate data. Water S.p.A. CFO confirms that advantages are related to efficiency increase in repetitive and low value adding activities and also to the possibility of letting controllers work more as business partners, focusing on Plan, Analyze and Advise activities, where human work can still bring value the most. The interviewee, in fact, agrees with the view of Finance function increasing its strategic relevance. In all projects described, controllers are not programming or performing data analytics, but they need to understand with considerable detail how do they work and the advantages they will bring to the business. They need to evaluate investments, which are often in the order of million euros, and evaluate their return. Therefore, at the moment, Finance is only indirectly impacted by Business Performance Analytics, but it is already prepared to embrace the upcoming revolution. According to the CFO, his department must "give light" to strategy, foreseeing where they will bring the company in the future and giving suggestions about what should be

corrected or modified. “Strategic advisor” can be therefore an adequate definition to what the future may reserve to Finance function.

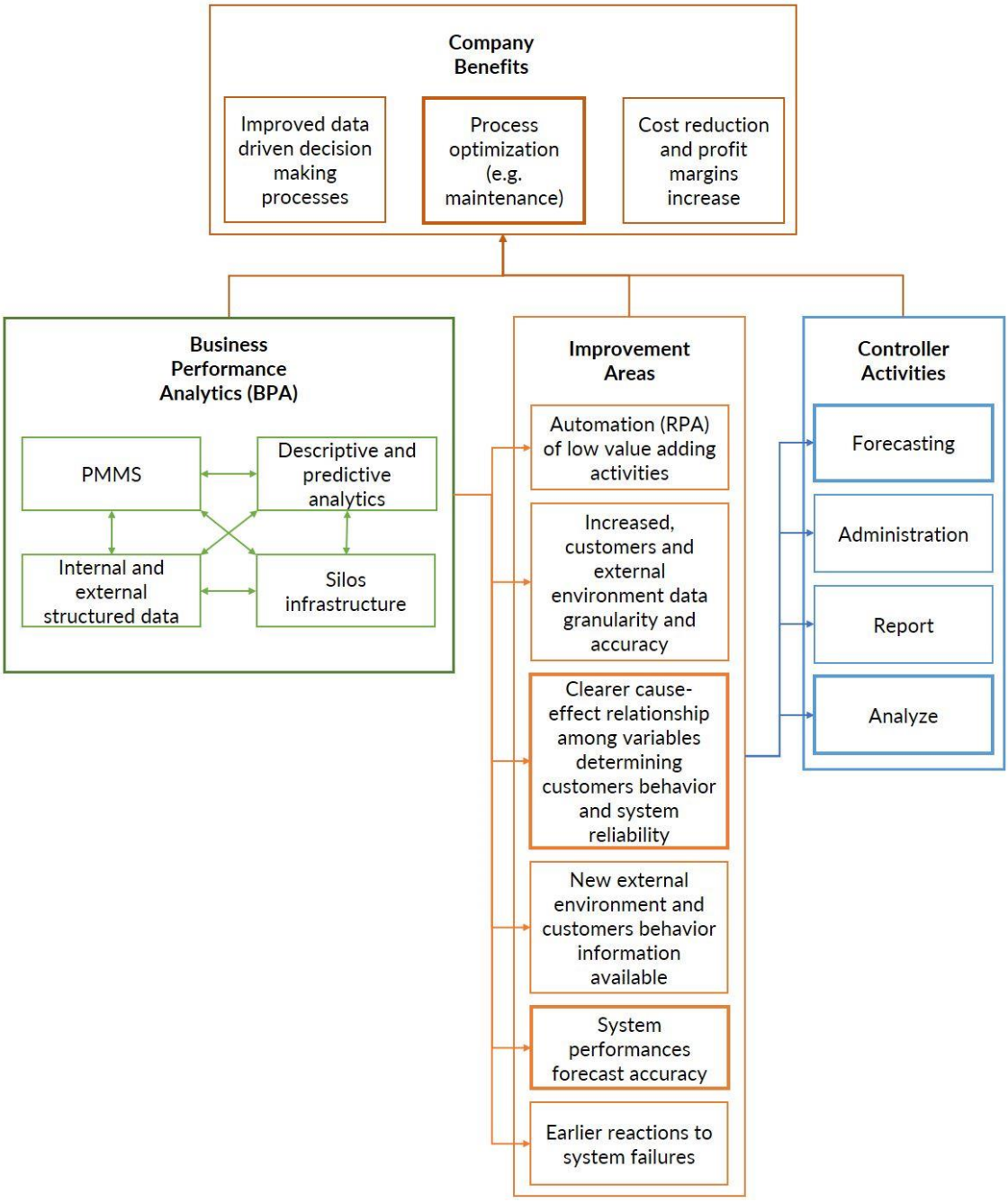


Figure 6-7, Water S.p.A. Business Performance Analytics framework

Referring to the framework, Water S.p.A. currently employs BPA to improve *Plan*, *Transact*, *Account*, *Report* and *Analyze* activities, especially in terms of *Robot Process Automation (RPA)* as regards mostly operational ones, while in terms of *Increased data granularity and accuracy*, *Clearer cause-effect relationship among variables*, *New*

information available, *Forecast accuracy* and *Earlier reactions* for those with more strategic relevance. Most relevant overall benefits are considered to be *Improved decision-making process*, *Process optimization* and *Cost reduction and profit margins increase*.

6.9 Pharma S.p.A.

6.9.1 Company overview

Industry	Pharmaceuticals
Revenues	50 B€
Employees	126000

Table 6-8, Pharma S.p.A. industry and dimension

Pharma S.p.A. is one of the biggest companies in its industry, that is pharmaceuticals. In fact, its revenues in 2017 have been around 50 billion euros, generated with 126000 employees. The interviewee covers the position of Chief Financial Officer in the European cluster, for one of the three main operating divisions of Pharma S.p.A. and managing therefore a perimeter of 10 countries and 1,5 billion euros turnover. This division is specialized in generic pharmaceuticals.

Business Performance Analytics is not only future projects, but also a solid reality. Centralized research has started several years ago, with the foundation of two Centre of Excellence in India and Spain, focused on cutting-edge data analytics techniques. The goal is to create a data-driven culture, uniform in the company. This confirms that Pharma S.p.A. believes in BPA as source of competitive advantage.

6.9.2 Pharma S.p.A. Business Performance Analytics

Centres of Excellence are the way chosen by Pharma S.p.A. to spread analytics culture and data analytics competencies around the company. This is not the only way to pursue these goals, and other two main possibilities exist. The first one is that every firm cluster, or subsidiary, starts its own projects, obtaining most likely highly customized solutions, that are also significantly different between each other. This would cause issues when consolidation necessities arise. The third solution is to ask external consultants support, that would be quicker to apply, since competencies would be already available and

developed. On the other hand, this would make more difficult culture to deep root inside Pharma S.p.A. Business Performance Analytics, therefore, is first risen in this Centre of Excellence context. Now that a first step of the project has been concluded and some bases established, it is possible to start decentralized projects. For example, thanks to a partnership with Politecnico di Milano, a fresh graduate is joining Pharma S.p.A. to develop local projects in parallel with Spain Centre of Excellence.

Talking specifically about BPA primary block, the interviewee explained that a unified data lake is currently under construction, managed by SAP software. It is going to collect three main types of data:

- Historical sales data:
- Historical competitors sales data;
- Historical production data.

Market data are provided by IMS Health, that is a monopolist and serves all pharmaceutical companies. Each type can be classified according to the category of medicine (e.g. cough and cold) and according to its chemical composition, up to molecular level. Analyzing historical data of the whole market it is possible not only to describe what happened in the past, but also to make accurate predictions about the future. Several data analytics techniques are applied, from basic statistics to advanced machine learning model, depending on the specific purpose. External environment data, however, are limited to those describing competitors' performances. Weather, for example, may be correlated to cough and cold diffusion, but at the moment it is not considered:

<<For our company, forecast accuracy is the most important goal looking at the framework, take note. When we set a budget for the next time horizon, every action taken in the company will follow that plan: a small variation can generate huge losses.>> Pharma S.p.A. European Cluster CFO.

The most sough advantage when performing predictive analytics is forecast accuracy, especially about global company performances. In fact, they generate firm's industrial footprint and shareholders expectations: all following actions will be undertaken accordingly. Predictive analytics support Pharma S.p.A. also when participating at public procurement processes, understanding what is the offer that maximize profit and probability to be chosen.

Robot Process Automation is extensively implemented in the company and can manage several Administration processes requiring basic Excel and SAP operations, therefore mainly Transact and Account activities. Invoices registration is an example. An important consideration it is that RPA is not an intelligent system. It is not able to improve itself, learning. It just repeats a series of predetermined operations. The main advantage of this new technology is that avoids controllers to use the largest part of their time doing "number crunching" that are low value adding activity.

Report activities have also been largely influenced by innovation projects. A new Business Intelligence software, provided by SAP, has been implemented and it offers similar features to Power BI by Microsoft, seen in the Nice House S.p.A. case study. Previously, preparing reports was a long and repetitive process, requiring data extraction from SAP to other software, and then the actual document was arranged. Right now, SAP BI allows to standardize main report types, and to avoid useless movement of data from one software to the other. Moreover, like Power BI, it makes possible to visualize reports from smartphones, simplifying the job of many employees. For instance, salesmen can quickly check their customers situation in terms of payments or orders to be received, while before they had to call offices and ask for this information. This example makes another important issue emerge, that is confidentiality of data. A salesman responsible of 200 pharmacies, for example, must be able to see reports summarizing data only from that group, and not all 17000 Italian ones. Considering the dimension of Pharma S.p.A. and the variety of existing roles, this is not a simple issue to manage. Future plans include the development of first a chat bot and then a vocal assistant providing customized reports.

Pharma S.p.A. Europe CFO also provided his view about the future of controllers and of Finance function. A first transformation of the role has been from accountant to controller, when management control, creating value challenging business, became a common practice. Now also controller is an obsolete term, and Business Planning Analyst (BPA) or Financial Planning Analyst (FPA) should be used instead. These roles will se an increasingly importance of data science competencies rather that economics ones, taken for granted. This is a disruptive change for many Finance employees, and companies must think about how to manage this change creating value for everyone. Centres of Excellence are a first answer from Pharma S.p.A., supporting sharing knowledge around the firm. Finally, the interviewee believes that the CFO already is CEO's "Strategic advisor". They

are expected to analyze reports, understanding key business drivers and defining strategies together. This kind of partnership between the two roles must work at every level in the organization between Finance and Business functions. Culture, that can be devoted for example to sales or to costs efficiency, is considered to be the main driver defining CFO and Finance function role in the company, and therefore the reason why different case studies gave different answers to this question.

Referring to the framework, Pharma S.p.A. employs BPA to improve *Plan*, *Administration*, *Report* and *Analyze* activities, thanks to *Robot Process Automation (RPA)*, *Increased data granularity and accuracy*, *Forecast accuracy* and *Earlier reactions*. Overall benefits sought are mainly *Improved decision-making process*, *Process optimization*, *Product optimization* and *Cost reduction and profit margins increase*.

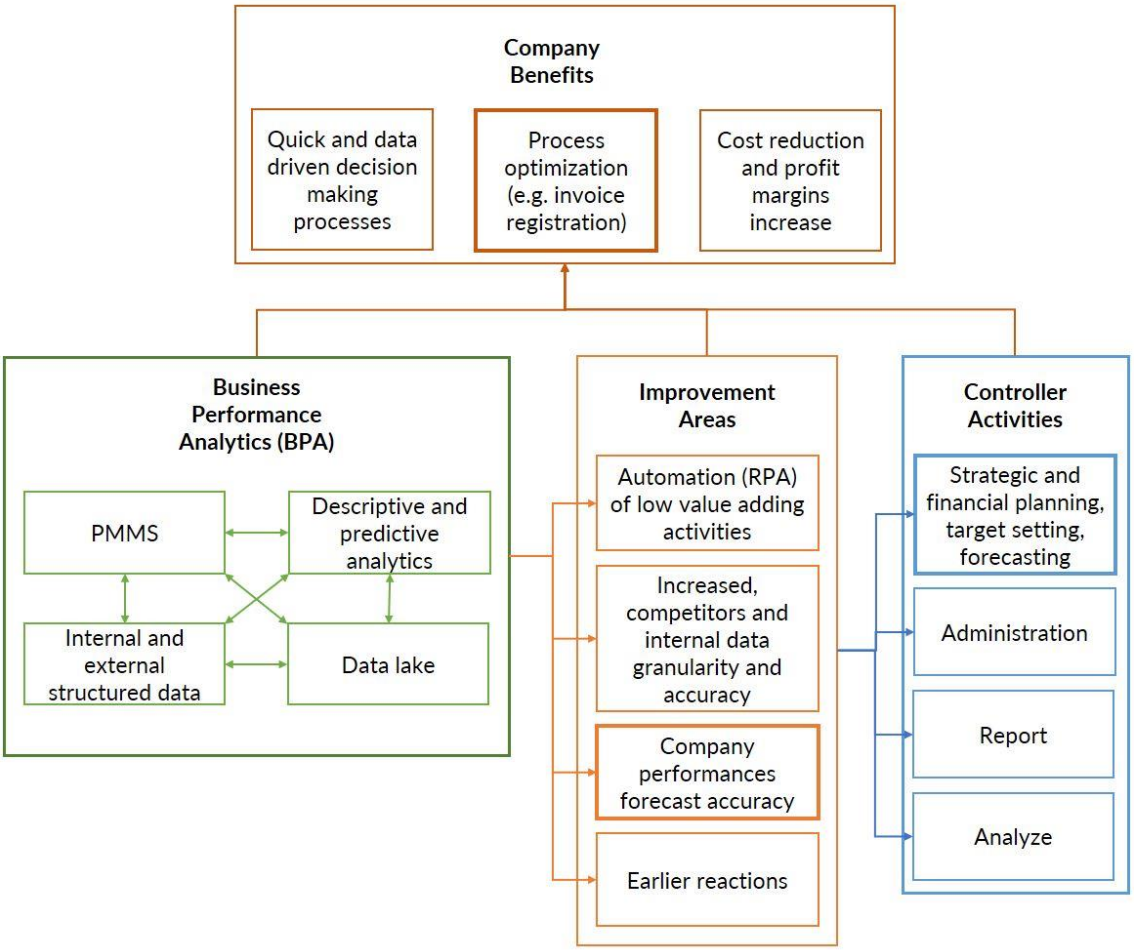
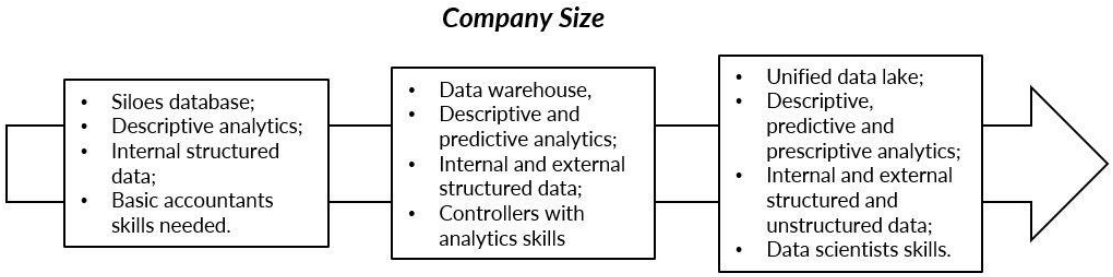


Figure 6-8, Pharma S.p.A. Business Performance Analytics framework

7. RESULTS AND DISCUSSION

In this chapter case studies and their adherence to the framework are analyzed comprehensively, to understand if it is adequate to describe reality and therefore to guide companies when starting a new project implementing a Business Performance Analytics system. In general, not only preliminary interviews with experts and practitioners, but also interviewees in companies approved the proposed theoretical BPA framework. The discussion is organized following framework structure and therefore its primary and then secondary blocks for *Business Performance Analytics (BPA)* and *Improvement Areas*. For *Controller Activities* and *Company Benefits*, it has been found clearer to develop the discussion in an organic way across the secondary blocks. This discussion will provide an answer to research questions addressing framework blocks and the relationship existing among them.

7.1 Business Performance Analytics (BPA)



Graph 7-1, Core papers classification highlighting a gap in literature

This primary block has clearly a strong influence on all others, since the most BPA components are developed in a company, the greatest is its effect on *Improvement Areas*, *Controller Activities* and *Company Benefits*. BPA diffusion and macro-configuration in terms of key components has been found to depend primarily on *Company Size*. While small companies, such as Glue S.p.A., can implement effective systems with a centralized data warehouse, bigger ones, e.g. Energy S.p.A. need unified data lakes to allow complex cross business line analysis. Case studies allowed to analyze different firm sizes, ranging from Small-Medium Enterprises (SMEs) to Fortune 500 companies. Large firms have both more need of BPA systems, that enable to analyze and find correlations between different business lines and markets, and capabilities to invest in technologies and competencies. Currently, being BPA systems still in the infancy of their evolution, other

drivers are still not definite enough. This has been suggested from several interviews, for example:

<<*When we kicked off our analytics project for performance management, we started looking for benchmarks, but didn't find any. This is something completely new not only for us, but for the market*>> Energy S.p.A. AFC Digital Hub - Chapter Leader Data Competence Center & Advanced Analytics.

7.1.1 Performance Measurement and Management System

The most relevant improvements regarding this secondary block regard the way these systems are implemented, rather than the systems themselves. In fact, budget, dashboards and other tools structures and principles did not change significantly What changed are the software behind their implementation, that allow automated preparation and a better visualization, especially in terms of clearness. Examples are Power BI by Microsoft seen in Nice House S.p.A. and SAP BI seen in Pharma S.p.A. The fruition of these tools also changed: cloud technologies make them available also in mobility, from tablets or smartphones. Not only biggest companies in the sample implemented these software, but also medium ones such as the already mentioned Nice House S.p.A. The SME analyzed, on the other hand, is still lagging on this aspect, with Excel sheets manually prepared to support dashboards or ABC computations.

7.1.2 Business Analytics

From case studies, it emerges that advanced analytics skills are still not so common, even among big companies' controllers. Machine learning and data mining techniques are diffused and implemented in several situations. However, the orientation is almost always predictive. Advanced prescriptive analytics in BPA systems have been observed only in one company, Energy S.p.A., that proved to be the most advanced in almost every field. There, it is common for analytics outputs to give already specific suggestions to controllers and to have a direct impact on their activities. In other firms, such as Liquid S.p.A., this analytics orientation is a solid reality but has an indirect impact on Finance function, since a dedicated Data Science business unit managing these processes exist. On the other hand, complex and advanced descriptive and predictive analytics are well established in the activities of most of the firms studied, while in a minority (Glue S.p.A., Tools S.p.A.) are basic or their implementation is planned in future projects. Advanced

applications can be the integration of several data sources, internal and external, to find out unknown correlations and improve forecast accuracy. It is common practice, for example, to purchase or extract autonomously competitors' data to understand market trends and benchmarking. Sometimes (Nice House S.p.A., Energy S.p.A., Water S.p.A.) these data are analyzed together with other external data such as weather, to produce accurate forecasts about company performances.

In general, all analytics orientations are considered necessary. However, descriptive and especially predictive analytics are the most developed and diffused. Company performances forecasts are drastically improved by analytics techniques able to integrate internal and external data and discovering new relationships among variables before unknown.

7.1.3 **Big Data**

A complete BPA system requires Big Data to be analyzed, but in most of the case studies in the sample, data analyzed cannot do not fully respect Big Data definitions given in the Literature Review chapter. Considering the three main Vs of Big Data paradigm, an high Volume is usually collected in companies' data warehouses or data lakes. When a developed ERP system is present, dimensions are already too big to be analyzed with traditional techniques; in most cases, these data are integrated with external databases, further increasing quantity and dimensions. Variety is the Big Data characteristic that usually is not respecting the definition. In fact, formats analyzed are almost always structured. Energy S.p.A. applies text analytics on competitors Financial Statements, to extract automatically relevant information, but few other applications have been observed. Often controllers deal with the output of unstructured data analyses. In fact, other functions, and especially marketing, are naturally more exposed to these formats, as Liquid S.p.A case study showed. Tools S.p.A. and Nice House S.p.A., the other firms for which final customers analysis is more important, are also planning to include in the short-term unstructured data in their databases, but marketing and sales function will be mostly involved in these projects. Social media analytics, including text analytics and image analytics, in fact, is one of the most diffused applications, and it addresses final consumers. Finally, Velocity of data was often under that expected from Big Data. Energy S.p.A.,

however, is conducting Near Real-Time analysis for many applications, an advanced solution consistent with Big Data paradigm.

In general, companies tend first to collect extended structured internal data, so that a quick win can is achieved, and predictive analytics can be adopted. Then, external structured data, about the market or external macro environment, follow. The last and most difficult step is unstructured data collection, both internal and external. However, it is not considered by most of the case studies in Finance function and therefore in a BPA context. Liquid S.p.A. in particular is sure that controllers will not have to deal with this type of data.

7.1.4 IT infrastructure

Case studies show that solutions applied in the market are still heterogeneous and depend on size but also necessities.

Talking about the *enabling infrastructure* and using the nomenclature defined in the Literature Review chapter, Glue S.p.A. and Water S.p.A. are using a siloes infrastructure, following therefore a traditional model, where each function can access directly only to its own data. Tools S.p.A., Fintech S.p.A. and Nice House S.p.A. instead implement a Centralized data warehouse, integrating all functions data and allowing cross-function analytics. Biggest companies, that are Energy S.p.A., Liquid S.p.A. and Pharma S.p.A., implement data lake solutions. In particular, Energy S.p.A. adopts a unique virtual data lake unifying those dedicated to single business lines. Solution to adopt, therefore, depend on company size and especially business lines' number. If they are many, integration becomes necessary to avoid time consuming and inconvenient data analyses.

The same heterogeneity has been found regarding *software*. To go into technical details is not the purpose of this research; what it is important to notice is that almost all companies are still using Excel sheets and Microsoft Office suite in general to guarantee flexibility, together with a more structured and integrated IT system, that in the sample is provided by SAP or Oracle. The latter requires significant investments, and that is why Glue S.p.A., the SME in the sample, did not implement this solution. Another category of software appreciated by users, is that allowing standard reports through cloud computing, consultable via portable devices such as the personal smartphone. This allows to save considerable amounts of time.

7.2 Improvement Areas

	Tools S.p.A.	Fintech S.p.A.	Glue S.p.A.	Liquid S.p.A.	Energy S.p.A.	Nice House S.p.A.	Water S.p.A.	Pharma S.p.A.	Relevant in (%) of case studies	Most important in (%) of case studies
Robot Process Automation (RPA)				**X**					62,50%	12,50%
Increased data granularity and accuracy		**X**			**X**				**87,50%**	25%
Clearer cause-effect relationship among variables	**X**		**X**		**X**	**X**	**X**		**87,50%**	**62,50%**
New Information available									62,50%	0%
Forecast accuracy							**X**	**X**	75%	25%
Earlier reactions									37,50%	0%

= *Relevant in the case study* **X** = *Most important*

Table 7-1, Improvement Areas primary block results summary

Improvement Areas primary block succeeded in describing effects researched by companies from Business Performance Analytics and can therefore be used in the future to better understand in which directions to go when starting this kind of project. Several examples have been pointed out during interviews, and a first result is that Clearer cause-effect relationship among variables and Increased data granularity and accuracy may be considered the most relevant. However, a quantitative study is needed to provide statistical evidence.

7.2.1 Robot Process Automation (RPA)

Repetitive and low value adding activities automation through RPA has been mentioned as a key advantage from 5 companies out of 8. Size does not seem to influence the answer. Liquid S.p.A. considers it as the most important one, consistently with his view of Finance function as not fundamental strategically. Interviewees recognize that Robot Process Automation has many applications in administrative controllers' activities. It is therefore a diffused technology, applications of which can be implemented in most companies. The most quoted example (Liquid S.p.A., Pharma S.p.A.) is invoices registration. It has been pointed out that it must not be confused with Artificial Intelligence, since, while the

former can only repeat a set of predetermined activities, the latter is more advanced and can learn how to perform new tasks.

7.2.2 Increased data granularity and accuracy

Other than Liquid S.p.A., all other firms mentioned this Improvement as a key advantage that Business Performance Management can provide. In particular, Fintech S.p.A. and Energy S.p.A. indicated it as the most important one. In the start up case, it allows to analyze performances of each employee, keeping track of every single operation performed on his/her workstation. Company culture is focused on hard working, and KPIs therefore follow this principle. In Energy S.p.A. the most important aspect of this improvement is not the granularity, but the accuracy. Investments, in fact, are focusing on consolidating data through a unified data lake. This makes sure that the meaning of a certain data is unequivocal. In other situations, may happen to find two that seem refer to the same performance or information, while they are not. Granularity may worsen this confusion without the unification on which the firm is heavily investing.

7.2.3 Clearer cause-effect relationship among variables

This improvement has been mentioned as key from all companies except for Pharma S.p.A. Furthermore, Tools S.p.A., Fintech S.p.A., Glue S.p.A., Energy S.p.A., Nice House S.p.A. and Water S.p.A. indicated it as one of the most important, that means 6 companies out of 8. This is a high value compared to that of other secondary blocks. Tools S.p.A. considers this improvement important especially related to the introduction of new products, since it can help understanding which variables contribute the most to the success of a new product line. Fintech S.p.A., on the other hand, is more focused on understanding which variables determine internal processes efficiency, focusing on employees' activities. Glue S.p.A. is also focused on costs, and in particular on how to easily find inefficiencies through ABC improvement. Energy S.p.A. is interested in its global performances and aims at discovering new cross business lines relationship that can increase the accuracy of their forecast. The same goal is shared from Liquid S.p.A., that however is planning to give part of this responsibility to a new Data Science business unit. Nice House S.p.A. wants to take strategic decisions, such as opening or closing stores and how, with a new awareness including new variables describing the external environment. Finally, Water S.p.A. controllers are indirectly but strongly affected by

projects identifying which variables can increase reliability and efficiency of their utilities network. It is important to highlight as often this improvement has been linked to another one that is *Forecast accuracy*. In general, it is diffused among companies the awareness that more variables must be considered in order to succeed in business, because hidden relationships exist among them. Controllers should share this mindset, and therefore do not discard information that look useless, unless it has been quantitively proved they are so.

7.2.4 New information available

This improvement is considered key from 5 companies out of the 8 included in the sample. Only Fintech S.p.A., Liquid S.p.A. and Pharma S.p.A., in fact, considers the availability of new information secondary compared to other advantages. No firm mentioned it as most important block, leading to the conclusion that what really adds value is how this information are used rather than their availability. New data collected, and information retrieved when developing a Business Analytics Performance project, can be internal related to company costs and processes, or external related to customers, competitors or external macro environment. Tools S.p.A. is mainly focused on better understanding new markets and therefore customers preferences and competitors offer key competitive advantages, to improve their positioning. Secondarily, it is also retrieving new information from processes considered noticeably inefficient, for example customer care process. Glue S.p.A. is interested in implementing a system able to summarize customers knowledge, in order to extract knowledge from their salesmen. Energy S.p.A., Nice House S.p.A. and Water S.p.A. are all interested in external environment information. A common example they shared is weather forecasts, that can be useful for all of them for different reasons. The three of them also share the need to extract new customers' information, need that is more compelling for Nice House S.p.A. because, while Energy S.p.A. and Water S.p.A. operate in utilities market, it works in a retail business where it is fundamental to understand customers' needs.

7.2.5 Forecast accuracy

Forecast accuracy is included among key advantages from 5 companies in the sample. Two of them, i.e. Water S.p.A. and Pharma S.p.A., believe it is the most important. As regards the former, it has an indirect but fundamental impact on controllers' activities,

since analytics allow to accurately forecast system reliability of their network and therefore its costs, that are also drastically reduced. On the other hand, Pharma S.p.A. recognize strategic importance to company's performances predictions, since they generate expectations in the top management and at all levels, setting the production blue print of the firm. Great emphasis in Finance function is therefore put on this aspect. The same point of view is shared by Energy S.p.A., while Nice House S.p.A. is focused on more punctual performances, such as new stores sales or current stores sales in specific periods, with high detail. Liquid S.p.A. brought the example of planning & control cycle, and especially budgeting, explaining how risk can be reduced performing what-if analyses on commodity prices and then invest on financial tools preventing losses from price variability. Business controllers are expected to execute these kinds of analyses, and therefore to always motivate their predictions with analytics. Finally, it is important to highlight again the relationship between this secondary block and Clearer cause-effect relationship among variables.

7.2.6 Earlier reactions

This improvement is sought when implementing BPA from Fintech S.p.A., Water S.p.A. and Pharma S.p.A., but none of the indicated it as the most important one. The start up is monitoring employees' KPI with high frequency and can take actions with proper timing. Water S.p.A. controllers, once again, are impacted indirectly by this improvement. Their activities effectiveness is increased, since when forecasting company performances and planning future investments they can rely on technicians' early reactions to possible issues. Finally, Pharma S.p.A. mentioned this improvement related especially to the availability of new software that allow to consult reports also from mobile devices. Employees do not have to wait to be in the office to consult data, or to call back to the company, but can do that whenever they want and wherever they are. Earlier reactions are therefore possible.

7.3 Controller Activities

The main result, considering *Controller Activities* primary block, is certainly the different influence that *Improvement Areas* have on operational and strategic activities. The former category, represented primarily by *Administration* (Transact, Account, Control, Comply) and secondarily Report, is impacted in all cases by Robot Process Automation (RPA)

improvement. They are considered repetitive and less value adding compared to strategic activities such as Plan, Analyze, Advise and, again, partially Report. Therefore, the goal is to reduce the time used by controllers to execute them through automation, and leave more time to perform the strategic ones, that instead are enriched in terms of potential and positive impact on company performances by other improvements.

Plan activities, are enriched by a better comprehension of relationships among variables, and therefore how non-financial and financial granular performances contribute to generate company success in terms, for example, of EBITDA, ROI or market capitalization. Firms plans therefore can better address key strategic drivers, through a better understanding not only of their internal processes, but also of the external environment thanks to the availability of new data and Business Analytics. Competitive intelligence, for example, is considered a key and necessary activity from many interviewees (Tools S.p.A., Liquid S.p.A., Energy S.p.A., Nice House S.p.A.). Analyze activities, and in particular performance analysis, of course, play a role in determining this new potential of Plan ones. Nice House S.p.A. showed in detail how new technologies allow to develop complex, but at the same time simple to use, Balance Scorecards. These dashboards empower managers in their daily decisions, but also act as a basis for longer term Plan activities such as strategic planning. For BPA to successfully and significantly support Advise activities, on the other hand, it is necessary to include advanced prescriptive analytics. In Finance function, this condition is met only from Energy S.p.A. among firms in the sample. As a consequence, while from a theoretical stand point the support that BPA can provide to these activities is solid, practical applications are still rare and should be investigated further.

Finally, Report activities have been included in both categories because their collocation depends, more than others, on company decisions. Liquid S.p.A. considers them as a mere execution from controllers of business users requests. On the other hand, Nice House S.p.A. recognize them the important responsibility of defining goals, since KPIs and information included are then those analyzed when making decisions. In this case, it is not possible to “just execute” business users requests, but they assume strategic relevance and must be carefully though by both employees.

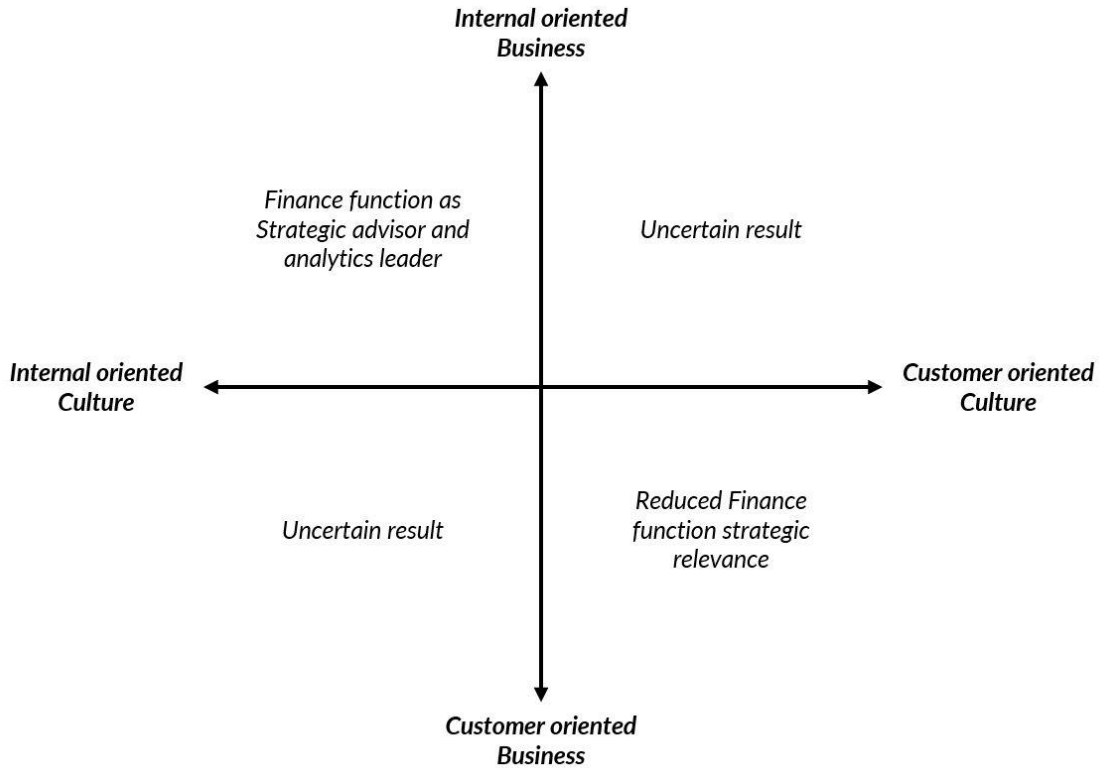
7.3.1 Finance function role evolution

These first results make possible to formulate some hypotheses on overall Finance function role evolution, topic already discussed from researchers and in Literature Review chapter as well. From this discussion, two opposite possibilities emerge for Finance function: evolving as CEO's "Strategic advisor" (Gary Cokins, 2014), and "ramp us as analytics leader" (T. H. Davenport & Tay, 2016), or to see their strategic relevance played down (Frey & Osborne, 2013). Even though this topic has not been directly addressed with a research question, interesting information emerged from case studies. Some of them (especially Energy S.p.A., Pharma S.p.A.) showed an increasing strategic relevance of Finance function; Pharma S.p.A. interviewee pointed out that controller is already an obsolete term, being substituted from other explicating a strong link with strategy, like Business Planning Analyst (BPA) and Financial Planning Analyst (FPA). Other case studies (especially Liquid S.p.A., Nice House S.p.A.) see Finance function to keep an operational role. Two factors have been identified, driving this evolution, that are Culture and Business. Despite the latter can influence the former, they are on some degree independent and can both determine the future of Finance function in a specific firm.

Business

Liquid S.p.A. interviewee points out that the relevance on function, and the scope of their influence, may depend on the Business and primarily on the type of customers served. If they are final consumers, the Marketing function will be top management focus and therefore the one holding more power in the company. Investments in analytics and technology, therefore, will be mostly directed there. In case of business customers, on the other hand, the quantitative attitude of Finance, and its transversal view of the business, may prevail when deciding which function should become analytics leader and strategic advisor. Nice House S.p.A. answer follows a similar logic: being an intermediary company, selling mostly to final consumers, their focus is on sales, while internal efficiency is considered less relevant determining firm performances. In both situations, interviewees did not forecast Finance function increasing its strategic relevance. Energy S.p.A. and Water S.p.A., on the other hand, operate in the utilities market, and sell commodities; Pharma S.p.A. works in pharmaceutical market, where consumers are more rational and internal costs, production but also research and development for example, are much more relevant. From these three companies emerged a different view of Finance

role evolution, coherent with Cokins (2014) and T.H. Davenport & Tay (2016) predictions. Their focus is more on internal processes and efficiency, while marketing is secondary. Business is therefore a first reasonable driver, that follows case studies suggestions.



Graph 7-2, Finance function role evolution

Culture

Culture, on the other hand, can also have significant influence. Energy S.p.A. interviewees suggests that company history and strategy have a strong influence on responsibilities distribution among functions. A firm whose culture is strongly internally oriented, on processes and efficiency will increase finance relevance, because of its natural role as costs controller, considering for example the budgeting process. Another firm whose culture is external and customer oriented, on the other hand, will need significant Marketing effort to accurately address consumers' needs, and make them aware of that. Two functions roles, therefore, are the opposite.

7.4 **Company Benefits**

Company benefits included in the block succeeded in describing what companies seek starting a BPA project. They all have been mentioned at least once, and interviewees have not suggested others to be added.

	Tools S.p.A.	Fintech S.p.A.	Glue S.p.A.	Liquid S.p.A.	Energy S.p.A.	Nice House S.p.A.	Water S.p.A.	Pharma S.p.A.	Relevant in (%) of case studies	Most important in (%) of case studies
Customer optimization and rationalization									12,50%	0%
Improved decision making process			**X**		**X**	**X**			**100%**	37,50%
Process optimization	**X**	**X**		**X**			**X**		87,50%	**50%**
Product optimization	**X**								25%	12,50%
Cost reduction and profit margins increase									**100%**	0%

Table 7-2, Company Benefits block results summary

= *Relevant in the case study* **X** = *Most important*

As expected, Cost reduction and profit margins increase is considered the final and main goal of every BPA project. Less predictable, Improved decision-making process and Process optimization are, according to case studies, second and third most important benefits for companies. The former has been mentioned in 100% of case studies, while the latter has been omitted only once, by Nice House S.p.A. The intermediary company insisted on its focus on customers and sales rather than internal efficiency, performance usually considered with Process optimization.

Decision-making processes improved are several and of different nature, for example those related to pricing, risk management or planning & control. They way they are improved, however, is the same and coherent with what has been described in Literature Review chapter: traditionally, much time in meetings is consumed by discussions based on opinions, different function by function. BPA allow to quantify a large part of these opinions, making the decision-making process more data driven, and therefore at the same time more efficient and effective.

Process optimization, as already mentioned, is addressed in terms of internal efficiency, that is in turn possible to divide in two categories.

- Efficiency of controllers' activities themselves, through RPA (Tools S.p.A., Fintech S.p.A., Water S.p.A.);
- Efficiency of other internal processes (e.g. customer care, maintenance) thanks to easier inefficiencies detection from controllers (Glue S.p.A., Liquid S.p.A., Energy S.p.A., Pharma S.p.A.).

Companies aim at improving both aspects, but the focus is highlighted citing them among brackets.

The two remaining benefits have been cited in actually few cases, one (Tools S.p.A.) for Customer optimization and rationalization and two (Tools S.p.A., Nice House S.p.A.) for Product optimization. For this reason, it is difficult to draft general results. A possible motivation is that these are goals of which Marketing function is usually responsible, and the impact on Finance therefore, if exists, is indirect as in the cases studied.

8. CONCLUSIONS

In this final chapter, final conclusions will be drafted, summarizing results and providing punctual answers to research questions posed in the Objectives and Methodologies chapter.

Even though Business Performance Analytics is recognized to possess a great potential improving companies performances, existing literature did not provide a comprehensive view of how this paradigm actually brings benefit, and where in the company, focusing instead on specific applications or adopting a technical view. Other researches focused on the implementation process, analyzing challenges, but an exhaustive study investigating its overall impact on the company was missing. The framework provided by this thesis contributes to fill this gap and adheres to reality, thanks to experts' interviews and exploratory case studies that, moreover, provide a first picture of BPA development in the Italian industry textile.

The framework answers to three main research questions.

RQ 1

<< What is the degree of diffusion of BPA systems among companies, in terms of key components (PMMS, IT infrastructure, Business Analytics, Big Data)?>>

To understand which Business Performance Analytics configuration to implement in a company, it is first necessary to understand what exactly it is, what are its components and the relationship among them, and a BPA primary block is therefore been included in the framework. Based on Silvi & Visani (2016), it exhaustively defines Performance Measurement and Management Systems, IT infrastructure, Business Analytics and Big Data role in the overall system and the links among them, while the case studies provided applications example. Synthetically:

- *PMMS*, which sets BPA system goals;
- *IT infrastructure*, which enables BPA system;
- *Big Data*, which act as BPA "fuel";
- *Business Analytics*, which manipulate *Big Data* through *IT infrastructure* tools to achieve goals set by PMMS.

Each of the four components has been further decomposed depending on key characteristics, and then investigated in case studies. While small companies, such as Glue S.p.A., can implement effective systems with a centralized data warehouse, bigger ones, e.g. Energy S.p.A. need unified data lakes to allow complex cross business line analysis. Case studies allowed to analyze different firm sizes, ranging from Small-Medium Enterprises (SMEs) to Fortune 500 companies. Large firms have both more need of BPA systems, that enable to analyze and find correlations between different business lines and markets, and capabilities to invest in technologies and competencies. Currently, being BPA systems still in the infancy of their evolution, other drivers are still not definite enough.

RQ 2

<< How do BPA improvement areas impact controllers' activities?>>

After clearly understanding all features and characteristics of a BPA system, its impact on Finance function and controllers' activities has been investigated, developing therefore the *Improvement Areas* and *Controller Activitie*s primary blocks. Previous articles, papers and preliminary interviews contributed to develop the theoretical framework, that was then successful in describing case studies applications. From them, it is possible to detect two main relationships, depending on two categories of *Controller Activities*:

- Operational →*Administration*, (*Report*);
- Strategic → *Plan*, *Analyze*, *Advise*, (*Report*).

Report activity cannot be place in a unique category, according to case studies results. While advanced robots, through *Robot Process Automation (RPA)*, are now able to execute most of the Operational activities, BPA is enriching and increasing the potential of the strategic ones, thanks to *Increased data granularity and accuracy*, *Clearer cause-effect relationship among variables*, *New information available*, *Forecast accuracy* and *Earlier reactions*. Detailed examples of the impacts have been firstly presented in the Case Studies chapter, and then summarized in the Discussion and Results one.

Finance function role evolution

These first results about BPA impact on controllers' activities make possible to formulate some hypotheses about Finance function role evolution, topic long debated in literature.

In fact, during exploratory case studies, it has been noticed that BPA strongly influences them. On one hand, it improves PMMS and their potential; on the other one, automate most controllers' activities through RPA. In previous research, as it has been considered in the Literature Review chapter, this influence has been analyzed; therefore, it has been considered useful to summarize case studies observations, to conciliate two different views about what will be the impact on Finance function role from changes brought from BPA in the company. In fact, while part of the research community argues that it has the right quantitative attitude and transversal view of the business to become CEO's "Strategic advisor" (Gary Cokins, 2014) and "ramp up as analytics leader" (T. H. Davenport & Tay, 2016), empowered by BPA, others believe that Robot Process Automation and Artificial Intelligence will take over controllers' main responsibilities, and that therefore their strategic relevance in the company will significantly decrease (Frey & Osborne, 2013). No unique answer has been found to this question. On the other hand, two main drivers of this evolution have been identified during exploratory case studies: Business and Culture. Therefore, characteristics of company's business, for example market and customers, together with its culture and strategy will determine the impact of BPA on Finance function role. While a business strongly influenced by consumers' needs and whose culture is oriented to customer service and product differentiation will most likely decrease Finance function strategic relevance, another business operating in a commodity market and culturally oriented to its internal processes and cost reduction will tend to move in the opposite direction.

RQ 3

<<Which advantages are pursued from companies implementing a BPA system?>>

The BPA system and its four key components enable several listed improvement areas of controllers' activities to generate which benefits in terms of company performances? The last research question closes the circle, to understand why a BPA project should be started. Benefits identified from existing literature and preliminary interviews succeeded in describing case studies' applications. Other than *Cost reduction and profit margins increase*, that is, not surprisingly, a key goal for all companies studied, *Improved decision-making process* and *Process optimization* have been found to be the most pursued *Company Benefits*. In fact, the former is achievable thanks to the data driven

approach guaranteed by BPA, while the latter is achieved automating controllers, repetitive activities, and making easier to identify inefficiencies in other processes. Other *Company Benefits* are matched in case studies, but rarely and indirectly. *Customer optimization and rationalization* and *Product optimization*, in fact, are often not directly addressed by BPA projects, but instead by other data analytics implementations in Marketing function.

It is important to highlight once again that, because of the qualitative nature of this study, results cannot be generalized. Nevertheless, they are satisfying: research questions have been answered and BPA framework is well suited to describe applications present in the industry. It can therefore serve as starting point for further research, that can investigate more in detail a specific block, or a specific relationship among blocks.

8.1 Limitations and further research

Despite the original contribution of the present thesis, limitations must be recognized and therefore future developments suggested. The research provides a comprehensive view of Business Performance Analytics and manages to draft general conclusions thanks to eight exploratory case studies; however, a focus on specific framework specific blocks is missing. For example, *Business Analytics* techniques employed in companies have been investigated in terms of descriptive, predictive and prescriptive orientations, but other more technical and relevant details regarding the techniques are missing. If statistical or deterministic models are applied, or which machine learning model, are issues not in the scope of this research, but that would add value to it. Another example is related to *IT infrastructure* secondary block: the thesis considers siloes, data warehouses and data lakes as possible solutions, while architecture details are scarce. The second important limitation to this research is the qualitative focus. Despite e first empirical demonstration has been provided by case studies, a complete quantitative analysis is missing. Relevance of each secondary block and relationships among them, therefore, are not statistically proved.

From this limitation rises the first suggestion for future research. The choice of a qualitative approach has been taken because of the infancy status of BPA literature and of industry applications. However, this thesis provides bases to change approach. In fact, several experts and practitioners approved the theoretical framework in preliminary

interviews, and exploratory case studies proved it matches with real scenarios. The second suggestion arises from the first mentioned limitation, concerning the development of secondary blocks. BPA framework would benefit from insights of each block, developing therefore researches focused on each of them.

Finally, future research should clarify towards which role Finance function and CFO are evolving. The thesis gave interesting insights from which it is possible ot develop a dedicated research

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