A process mining impacts framework

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Abstract

Purpose: Process mining (PM) specialises in extracting insights from event logs to facilitate the improvement of an organisation's business processes. Industry trends show the proliferation and continued growth of PM techniques. To address the minimal attention given to developing empirically supported frameworks to assess the nature of impact in the PM domain, this study proposes a framework that identifies the key categories of PM impacts and their interrelationships.

Design/Methodology/Approach: The qualitatively derived framework is built, re-specified and validated from a diverse collection of 62 PM case reports. With multiple rounds of coding supported by coder corroborations, inductively extracted concepts relating to impact from a first set of 12 case reports were grouped into themes and sub-themes to derive an *a-priori* framework by adopting the Balanced Scorecard as a theoretical lens. Concepts from the remaining 50 case reports were deductively grouped to re-specify and validate the proposed PM Impacts Framework. Further analysis identified interrelationships between impacts, which extends our understanding of the identified PM impacts.

Findings: The proposed framework captures PM impacts in four main categories: (a) *impact on the process,* (b) *customer impact*, (c) *financial impact*, and (d) *impact on innovation and learning*. We extended our analysis to identify the interrelationships between these categories, which vividly demonstrates how *impact on the process* mediates the attainment of the other three impact types.

Originality: The need for a deeper understanding of PM impacts within the context of contemporary PM practice is addressed by this work. Our PM Impacts Framework provides a classification of PM impacts into four categories with 19 subcategories. It also identifies direct, moderating and mediating relationships between categories and subcategories whilst highlighting the role of *impact on the process* as a precursor to the other types of PM impact.

Keywords: Process mining; process mining impacts; business process management; Balanced scorecard; Success; Impacts.

Paper type: Research paper

1. Introduction

The process mining (PM) research field specialises in techniques that extract insights from Information Systems (IS) using readily available event logs (van der Aalst *et al*., 2012; van der Aalst, 2016). It draws from computational intelligence, Data Mining (DM), and Business Process Management (BPM) to enhance business processes. Key PM capabilities include process model discovery, monitoring performance indicators, identifying bottlenecks and resource constraints in a business process, and assessing regulatory performance (van der Aalst, 2016). Several tools and techniques have been developed and applied in various contexts with promising results (van der Aalst, 2010).

Industry considers PM a tool that monitors and improves business processes to facilitate operational excellence (Sneddon, 2021). There is a growing interest in PM in diverse fields, such as audit (e.g., Jans *et al*., 2013), healthcare (e.g., Rojas *et al*., 2016), insurance (e.g., Wynn *et al*., 2019), and financial services (e.g., Buijs *et al.,* 2019). In 2019, Gartner[1] estimated PM licence and licence maintenance revenue at US$320 million. The global process analytics market trends indicate a Compound Annual Growth Rate (CAGR) of 50%, expected to reach US$1.42 billion by 2023[2]. Deloitte's 2021 global process mining survey of 106 IT and Business executives indicated that 67% of respondents had started PM implementation, 87% of non-adopters were planning to conduct pilot runs, and 83% of responders believed PM delivers value[3].

Despite current demand and predicted growth in PM use, issues relating to PM impacts, the means of deriving such impacts and their potential interrelationships within organisations remain largely unexplored. While opportunities and challenges for PM in organisations have been explored (Martin *et al*., 2021), calls are made to pay more attention to further investigating issues related to PM in practice (vom Brocke *et al*., 2021a). Much of current PM research is skewed toward *technical* aspects, such as algorithm design and development, leaving *managerial* aspects such as governance, culture, and

[1] Available at https://www.gartner.com/doc/reprints?id=1-24ARMY34&ct=201002&st=sb
[2] Available at https://research.aimultiple.com/process-mining-stats/
[3] Available at https://www2.deloitte.com/de/de/pages/finance/articles/global-process-mining-survey-2021.html

adoption with significant research gaps (Grisold *et al*., 2020; Syed *et al.*, 2020; vom Brocke *et al*., 2021a).

While process managers acknowledge the benefits of PM, especially as a process efficiency tool (Grisold *et al*., 2020), the much-needed value assessment mechanisms to make a business case with senior executives are lacking. Existing attempts to assess PM impact provide only anecdotal narratives of successful PM initiatives (e.g., Reinkemeyer, 2020) or outline impact factors from a single stakeholder perspective without consideration of how these factors interrelate (e.g., Decker, 2019). As a result, the value that PM brings to organisations is not fully understood and hinders the potential of PM to provide optimum value and efficacy as a technology investment (Mans *et al*., 2013). Thus, a framework that consolidates the existing perspectives to ascertain a comprehensive view of PM impact is needed and would greatly help to justify the significance of PM in organisations and motivate its continued use.

Our paper, therefore, sets out to answer: *How can PM impacts and their interrelationships be conceptualised?* We consider PM impacts from the viewpoint of evaluating the successful deployment of PM projects within organisations. This study focuses on PM success stories from diverse perspectives. The negative impacts of PM and lessons learnt from failed PM initiatives fall beyond the study scope. We, therefore, propose a working definition for PM impacts as "*any immediate or long-term outcome or series of outcomes which are directly or indirectly attributable to the use of process mining in an organisation."* Our study presents a PM Impacts Framework that systematically identifies key PM outcomes, how they are derived, and in what ways they bring transformation to the organisational context. Note that, PM Critical Success Factors (CSFs), which are antecedents to PM impacts, are beyond the scope of this paper and are not explored here.

The paper is structured as follows: Section 2 discusses related work, followed by the research design (Section 3). Section 4 details the PM Impacts Framework, while Section 5 presents the discussions, contributions, limitations, and future work. We conclude our paper in Section 6.

2. Related Work

This section synthesises prior literature on impact from PM and related domains following a 'narrative' style literature review (as per Pare *et al*, 2015). Note that diverse terms such as *success*, *value*, *effects,* and *benefits* have previously been used to describe the notion of impact in the literature. We considered these terms in our quest for related work. However, we position our work as an impact study.

2.1. Prior research on PM impacts

The earliest work on PM success by Mans *et al*. (2013) proposes an empirically validated PM success model that identifies six success factors (e.g., Management support, Resource availability) and three success measures. A recent PM success factor model by Mamudu *et al*. (2022) re-specifies and extends the work by Mans *et al*. (2013) using evidence from more than 60 PM case reports. They identify nine success factors and explain how these factors relate within the PM context to optimise PM success. However, this study does not explore PM impacts.

Decker (2019) also investigates PM success; in particular, they identify five success factors and four PM impact factors (*automatic discovery*, *transparency*, *analytical capability* and *achieving strategic objectives*). However, their study focuses on a single stakeholder perspective and does not address potential relationships between the identified PM impacts.

Eggers and Hein (2020) explore the value realisation potentials of PM from several organisational contexts but are limited to making propositions for future research into PM implementation, PM use and value realisation potentials.

vom Brocke *et al*. (2021a)'s five-level PM research framework discusses contextual considerations for how PM effects are likely to unfold at five levels: *technical*, *individual*, *group*, *organisational* and *ecosystem*. While they identify specific areas of interest and key theories to further develop PM research, this framework neither provides details on what specific PM effects might mean for PM adopters nor the means for attaining such effects.

Aside from academic literature, several industry reports, case reports[4], working papers and website articles[5] from the practitioner community have also tried to quantify the benefits of PM or capture successful PM use-case scenarios. For instance, Reinkemeyer (2020) provides a PM user's perspective on 12 use-cases from different industry sectors which have successfully used PM for different purposes and obtained tangible benefits. The Task Force for Process Mining[6] (TF-PM) also holds a repository of PM success stories written by tool vendors and practitioners. While these cases collectively vividly capture successful PM scenarios, each on its own merely provides anecdotal narratives from a single-stakeholder perspective.

From the existing PM literature above, we note that most prior work is focused on success factors rather than PM impacts. While the significance of understanding PM impacts is discussed (Mans *et al*., 2013), the literature to date lacks empirical work and has left this as a recommendation for future research (Decker, 2019; Eggers and Hein, 2020). The practitioner community has provided successful use-case scenarios, but these tend to be anecdotal (e.g., Reinkemeyer, 2020). As a result, unanswered questions still remain on PM implementation, use and value realisation potentials across several levels of the organisation (Eggers and Hein, 2020; vom Brocke *et al*., 2021a).

2.2. Success studies in related domains

Since the available literature on PM impacts is limited, we have reviewed existing literature in three related domains; BPM, as it is considered to be the mother-domain of PM (van der Aalst, 2016), DM and IS. The DM domain was selected because classical supervised and unsupervised learning techniques of DM form the foundation of some PM techniques, making it one of the main pillars of PM (van der Aalst, 2016). Lastly, since PM is a technology-driven approach, the IS domain – which has some well-established impact frameworks, was also considered.

[4] Use-cases and success stories are similar names used by other authors to refer to case reports of PM projects.
[5] 11 Benefits of PM in 2021 according to practitioners. Retrieved 5th June 2021 from https://research.aimultiple.com/process-mining-benefits/
[6] Task Force for Process Mining (TF-PM) online repository. Retrieved 5th June 2021 from https://www.tf-pm.org/resources/casestudy. Number of cases, current as of retrieval date were 43.

2.2.1. Business process management (BPM)

BPM research has widely explored success factors theoretically and empirically (e.g., Alibabaei *et al*., 2009; Dabaghkashani *et al*., 2010; Antonucci and Goeke, 2011; Hribar and Mendling, 2014) and has proposed success models for BPM. Poelmans *et al*.'s (2013) success model tests how *system, information,* and *service quality* impact user evaluations such as *perceived usefulness* and *user satisfaction* of BPMS (business process management system) applications in operational activities. Their empirically validated model introduces new constructs for assessing BPM Success such as *input quality*, *generic system attributes* and *BPMS-specific attributes* (such as *allocation* and *routing quality*). Thompson *et al*. (2009) also propose a success model that captures *process quality*, *process efficiency* and *process agility* as the three dimensions of process success, and *cost efficiency*, *client experience* and *business agility* as dimensions of business success. However, this success model is specific to the banking sector.

Also, in business process simulation where performance indicators are used to analyse and predict expected future behaviour of process models (Wynn *et al.*, 2007), emphasis has been on leveraging innovative simulation approaches. Some success stories have been published (eg: Hunt *et al.*, 1997) with limited studies on critical success factors (eg: Hlupic *et al*., 2000). To the best of our knowledge, no success models have been proposed in this area.

2.2.2. Data mining (DM)

Predominantly, DM success studies have explored the role of critical success factors for DM success (e.g., Nemati and Barko, 2003; Hilbert, 2005). Others such as Bole *et al*. (2015) have proposed a conceptual DM success framework for measuring success in embryonic DM implementation. They identify three critical success factors and four DM implementation success measures (*top management support*, *net benefits*, *intention to use* and *information quality*).

Another key framework for strategic value creation in the Big Data Analytics (BDA) domain by Grover *et al*. (2018) provides a systematic approach to transition from *BDA infrastructure* and *BDA capabilities* to *value creation mechanisms*, *value targets*, and *impact*; taking into consideration moderating factors. The BDA value framework captures capabilities and value realisation potentials that likely pertain to

the PM domain. However, due to the BDA value framework's generic nature, certain proposed value creation mechanisms and value targets fall beyond the scope and capabilities of PM as an analytical technique.

2.2.3. Information Systems (IS)

The IS domain has a long-standing research tradition regarding systems evaluations (Tate *et al*., 2014). These studies have focused on justifying the value of IS investments by either investigating contextual influences on IS success (e.g., DeLone and McLean, 1992; Seddon, 1997; DeLone and McLean, 2003; Gable *et al*., 2008), understanding the business value realisation potentials of IS performance (e.g., Melville *et al*., 2004; Kohli and Grover, 2008) or using more generic approaches such as the Balanced Scorecard to measure IS performance (Kaplan and Norton, 1992; Martinsons *et al*., 1999, Kaplan and Norton, 2000).

A seminal work which provided a unified conceptualisation of the diverse views of success in IS was by DeLone and McLean (1992). The DeLone & McLean IS success model is a taxonomy of six dimensions; *system quality*, *information quality*, *use*, *user satisfaction*, *individual impact,* and *organisational impact* as the main dimensions of the "*dependent variable*" (Tate *et al*., 2014; DeLone and McLean, 1992). However, the DeLone & McLean IS success model has been critiqued for having an insufficient explanation of its underlying theory. Attempts to empirically determine its causal/process nature have also yielded mixed results (Gable *et al*., 2008). Subsequent studies have modified, re-specified, extended or assessed the interrelatedness of its variables with other independent variables (e.g., Seddon, 1997; Rai *et al*., 2002; DeLone and McLean, 2003). Gable *et al*. (2008) re-conceptualise IS success using a formative and multi-dimensional model that provides a benchmark for monitoring IS performance based on current and anticipated net benefits from an IS as perceived by relevant stakeholders. Their empirically validated model takes a "*point in time*" view of success by measuring *individual* and *organisational impact* to date and assess *system quality* and *information quality* to predict probable future impacts.

In existing IS business value literature, the common notion of "*value*" implies an economic benefit derived from IS performance (Schryen, 2013). Given this, studies in this domain have mainly assessed

the success/impact of IS using objective financial indicators such as return on investment and return on assets (Tate *et al*., 2014). However, others hold a contrary view. The recent pervasiveness of IS in business has revealed that IS value manifests in many forms beyond financial benefits (Kaplan and Norton, 2000; Kohli and Grover, 2008; Tate *et al*., 2014).

With performance measurement tools such as the Balanced Scorecard (Kaplan and Norton, 1992; Kaplan and Norton, 1996), organisations have been able to assess overall performance by supplementing financial measures with three other perspectives: *customer*, *internal process*, and *innovation and learning* making the Balanced Scorecard a more comprehensive metric for assessing IS impact (Kueng, 2000). Consequently, it has been adopted for IS strategic implementation, Information Technology (IT) planning and aligning IT for strategic organisational IT objectives (Kettunen and Kantola, 2005; Martinsons *et al*., 1999; Van Grembergen and De Haes, 2005).

Mooney *et al*. (1996) and Kohli and Grover (2008) have also stressed that beyond the financial and non-financial measures, IS business value affects intangible assets such as organisational capabilities (Schryen, 2013). In view of this, some existing work has confirmed that the first level of IS impact in the organisation occurs at the process/intermediate level, followed by the organisational level (Mooney *et al*., 1996; Tallon *et al*., 2000; Melville *et al*., 2004).

2.2.4. Summary of key findings and gaps from literature

In summary, existing literature from the related domains addresses IS success in detail. While some works focus on success factors (e.g., Alibabaei *et al*., 2009; Antonucci and Goeke, 2011; Nemati and Barko, 2003) which is beyond our study scope, others also propose interrelationships between high-level constructs such as *system quality*, *use* and *impact* (e.g., DeLone and McLean, 1992, Gable *et al*., 2008, Thompson *et al*., 2009, Bole *et al*., 2015). IS business value literature and generic tools such as the Balanced Scorecard also address the financial and non-financial benefits of IS (Mooney *et al*., 1996; Kohli and Grover, 2008; Kaplan and Norton, 2000). Existing PM impact literature that attempts to conceptualise PM impact either propose value realisation potentials with no specific means of attaining these outcomes (e.g., vom Brocke *et al*. 2021a) or at best consider a single stakeholder perspective of

PM impact (e.g., Reinkemeyer, 2020). The bullet points below summarise key findings and gaps identified from the literature:

i. **PM impact literature:** Covers PM success factors, and propose value-realisation potentials for PM. But provides no or only anecdotal evidence of PM impact, and that too scattered – only capturing narrow, individual perspectives at a time.

ii. **BPM literature:** Proposes BPM success factors and reports on BPM success models. But BPM is much broader (an entire field/ discipline) than PM. How these insights may (or may not) relate to the PM context is not discussed.

iii. **DM literature:** Proposes DM success factors and there are also DM value realisation frameworks. Similar to above, while PM and DM have similarities (e.g., both are data driven approaches influencing organisational decisions), if and how DM success can relate to PM success is not discussed.

iv. **IS literature:** Proposes IS Success models, IS Value realisation models and generic models for measuring IS performance. While there is notable maturity in the discourses of IS success, how much of this is applicable to the specific PM domain, is to-date, unknown.

Considering industry's current view of PM as an operational excellence tool for process improvement initiatives (Sneddon, 2021), a detailed conceptualisation of PM impacts derived from a multi-stakeholder perspective with underlying explanations of causal paths and interrelationships will prove highly beneficial to the PM domain. A synthesis of existing PM case narratives is seemingly a useful source for this (this is explored further next).

3. Study Design

Our study applies an in-depth qualitative analysis which builds, re-specifies, and validates a comprehensive PM impacts framework. This section outlines how the data was sourced and details the analysis procedures followed.

3.1. Sourcing the data

Our data is sourced from three publicly available case report repositories within the BPM/PM community. These cases highlight PM implementation projects written from PM user, vendor and practitioner perspectives on the success stories and direct benefits from PM. They share the narrative of a diverse range of process mining practitioners across the globe. PM case reports are noted to focus on applying PM techniques in specific organisational contexts (Martin *et al*., 2021), thus providing rich insights into PM use and outcomes within specific contexts.

An overview of these cases is provided in Part A of the Appendix. These cases were grouped into two pools for two distinct purposes:

i. Pool 1 was used to derive the *a-priori* framework. It consisted of 12 case reports, published in "Process Mining in Action" by Reinkemeyer (2020), written from a PM user perspective, capturing the "tangible benefits and lessons learnt" of PM by various organisations over a minimum period of two years.
ii. Pool 2 was used for re-specifying and validating our proposed framework. It consisted of 50 success stories on PM projects from tool vendor and software practitioner perspectives. 42 of these cases were obtained from the Task Force for Process Mining (TF-PM) online case reports repository[7], and eight cases from the BPM cases (Volume 1 and 2) (vom Brocke and Mendling, 2018; vom Brocke *et al*., 2021b).

Note that the 62 case reports from the three identified sources were current as of 5th June 2021- when this study's paper extraction took place. They provide a rich collection of the PM experiences of over 50 organisations from multiple sectors, such as manufacturing, healthcare, finance, and technology, in areas including Customer Relationship Management (CRM), governance, Supply Chain Management (SCM), and audit and compliance and are, we believe, representative of current PM practices.

[7] As of 5th June 2021, there were 43 case reports in the TF-PM online repository. 42 cases in English and 1 in German. The 42 English cases were analysed for this study.

3.2. Data Analysis

Following Dubois and Gadde (2002) and Dubois and Gadde (2014), we applied a hybrid (abductive) analysis approach, using both inductive and deductive coding. A qualitative analysis tool, NVivo 12, was used to manage and support the end-to-end data analysis process. Coding rules and guidelines were set and applied (Saldaña, 2012) as presented in Appendix – Part B. Data analysis consisted of three main phases: Phase 1 – identifying *a-priori* PM impacts, Phase 2 – re-specifying and validating the identified impacts and related terms, and Phase 3 – identifying potential factor interrelationships.

3.2.1. Phase 1: Identifying *a-priori* PM impacts

To derive our *a-priori* PM Impacts Framework, we conducted a first coding cycle using the in-vivo coding method to extract low-level codes from Pool 1 and label the ideas using actual phrases or "indigenous terms" (Saldaña, 2012) from the case reports that connote impact, value, or benefits derived from PM initiatives. Where necessary, multiple codes were applied to any fragment of a sentence that captured multiple connotations of PM impacts. Researcher comments and coding reflections were captured using annotations and memos[8]. After the first coding cycle, 171 in-vivo codes connoting PM impacts were extracted.

We commenced axial coding (Saldaña, 2012) by grouping similar in-vivo codes to form higher-level themes (see Appendix Part E, Section E.1 for an example). The Balanced Scorecard (Kaplan and Norton, 1992; Kaplan and Norton, 1996) was adopted as a classification scheme for the derived axial codes during the sense-making process to accommodate the diverse facets of the themes derived from axial coding. We mapped the emerging themes as sub-themes to the four Balanced Scorecard perspectives: *internal process*, *customer*, *innovation and learning* and *financial*. Matrix intersection[9] features were also used to eliminate redundancy, overlapping constructs or confusing classifications.

[8] Annotations and Memos allow researchers to capture their thoughts and reflections during the coding process. They allow the researcher to think critically about their choice of codes and why these codes must be captured.
[9] Matrix intersection search is a "*two-dimensional type of Boolean search made available through NVivo. It takes the searched feature from two collections at a time, and finds passages in the documents or nodes, in which the search term is contained in both*." (Bandara, 2006).

3.2.2. Phase 2: Framework re-specification and validation phase

In this phase, deductive analysis of new evidence from the 50 case reports in Pool 2 was used to re-specify and validate the *a-priori* PM Impacts Framework.

Similar to Phase 1, low-level codes were first inductively extracted from Pool 2 case reports using the in-vivo coding method, to ensure that potential new ideas emerging from the Pool 2 case reports were captured. This resulted in 507 coding references. These low-level codes were deductively mapped to the identified themes and sub-themes of the *a-priori* PM Impacts Framework. In total, 678 coded references were extracted from Pool 1 and Pool 2. Four themes and 19 sub-themes were derived which formed the categories/subcategories for our proposed PM Impacts Framework.

3.2.3. Phase 3: Identifying possible interrelationships

We sought to identify patterns and inherent relationships between the four categories and 19 subcategories for our framework. During in-vivo coding, memos and annotations were created to capture evidence-based interrelationships, and these were contextualised using scenarios from the case reports. Matrix intersection and near search queries were run to elaborate direct and indirect (specifically, moderating and mediating) relationship forms in the case context and help explain how these categories/subcategories may interrelate for PM impact (see Appendix Part E, Section E.2 for an example).

3.2.4. Ensuring validity and reliability of qualitative content analysis

To ensure the validity and reliability of the qualitative coding process, a coding rulebook was designed, and coder corroboration sessions were applied (as detailed in Appendix Part B). The use of NVivo 12 enabled us to increase the transparency and efficiency of the coding process.

The coding rulebook was essential to ensure a formalised operationalisation of the extracted codes (DeCuir-Gunby *et al*., 2011). This was an iterative process because as the study progressed and more precise insights were obtained from the case report texts, definitions and coding procedures were revised. Coder corroboration sessions were an integral part of the approach, which enabled quality assurance of the coding process and enriched the interpretations obtained through the analysis steps. It is also recommended that qualitative analysis be performed by multiple persons to increase

comprehensiveness and sound data interpretation (Elo *et al*., 2014). Coding quality checks began with a thorough comparison, discussion, and review of independently extracted low-level codes from an initial set of three out of the 12 case reports in Pool 1, which ensured a unified understanding of the coding techniques and context. Subsequently, codes extracted from the remaining nine case reports were discussed and reviewed accordingly. Coder corroborations continued during sense-making and code groupings for the framework building and framework re-specification phases.

4. Findings

This section describes our proposed PM Impacts Framework and the relationships between its categories/subcategories.

4.1. PM Impacts Framework

Our data analysis (see Section 3) resulted in a framework with four key categories and 19 subcategories, as summarised in Figure 1. The subcategories are defined in Table I, below, along with the supporting evidence, i.e., the number of instances where an impact was referred to in the cases. Each category and its corresponding subcategories are described in more detail below, and relevant quotes from the case reports are provided in the Appendix Part C.

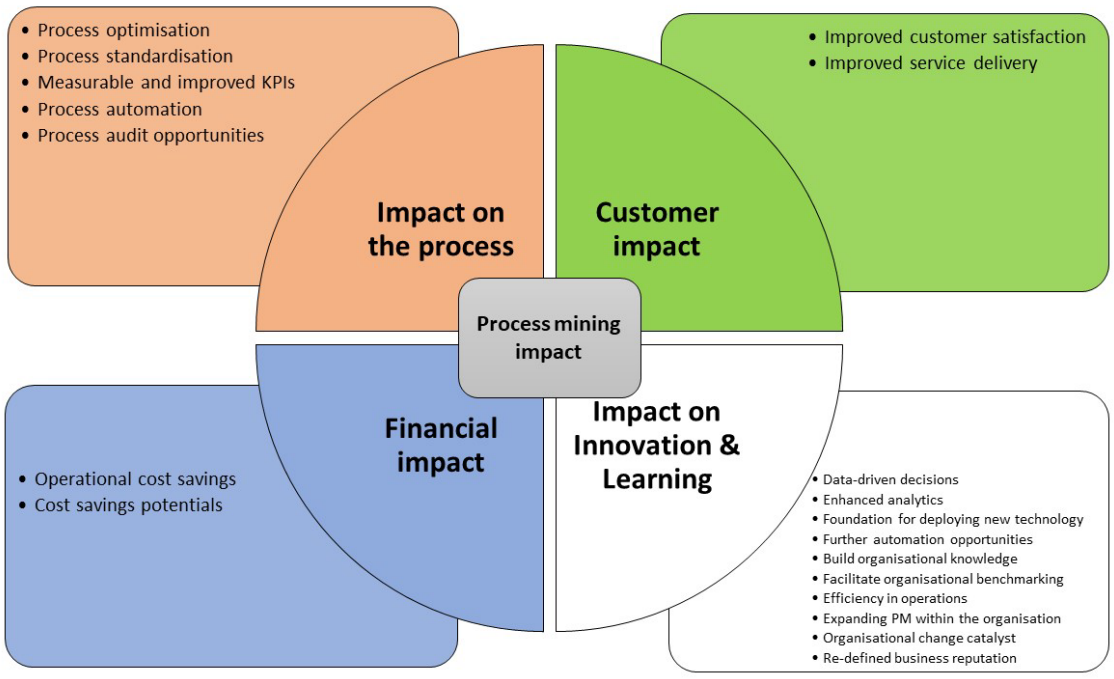

Figure 1: PM Impacts Framework

Table I Impact categories and subcategories with supporting evidence from the case reports

Category/ Sub-category	Description	Case evidence summary
Impact on the Process: any impact that results in a direct modification or re-designing of the business process.		**117 instances from 44 cases**
i. Process optimisation	An impact on an organisation's process resulting from actions taken to make business processes more efficient and of higher quality by minimising rework and throughput times.	62 instances from 32 cases
ii. Process standardisation	An *impact on the process* that results from aligning business processes to best practices or pre-determined benchmarks. For instance, comparing similar processes within an organisation's units to uncover process variants and benchmarking these processes with established best practices.	18 instances from 13 cases
iii. Measurable and improved Key Performance Indicators (KPIs)	Adopting effective ways to measure and improve Process KPIs. This is usually based on the actions taken with regards to the insights received about an existing business process.	16 instances from 15 cases
iv. Process automation	Automating a standardised or well-defined business process.	15 instances from 11 cases
v. Process audit opportunities	The opportunity for organisations to engage in process audits.	6 instances from 3 cases
Customer Impact: any impact that directly improves the service provided to an organisation's customers.		**15 instances from 13 cases**
i. Improved customer satisfaction	Enhanced level of satisfaction to clients	9 instances from 6 cases
ii. Improved service delivery	Enhanced level of service delivery to clients	6 instances from 6 cases
Financial impact: any impact directly relating to cost savings or creating savings potentials in the organisation.		**23 instances from 16 cases**
i. Operational cost savings	Savings benefits derived from running operational activities efficiently.	17 instances from 11 cases
ii. Cost savings potentials	Opportunities for future cost savings.	5 instances from 4 cases
Impact on Innovation and Learning: any impact that generates knowledge within the organisation or creates a key transformation in the organisation's operations. For instance, *efficiency in operations* gained from re-structuring business functions to meet changing trends.		**102 instances from 33 cases**
Innovation: impact that generates a key transformation in the organisation's operations.		**31 instances from 19 cases**
i. Data-driven decisions	Making decisions from a data-informed perspective	10 instances from 8 cases
ii. Enhanced analytics	Improved level of data analytics within the organisation.	6 instances from 4 cases
iii. Foundation for deploying new technology	The ability to facilitate the deployment and integration of new technology investments within the organisation.	6 instances from 5 cases
iv. Further automation opportunities	Opportunity to embark on large-scale automation of the organisation's business processes.	9 instances from 5 cases

Learning: impact that generates knowledge within the organisation.		**16 instances from 8 cases**
v. Build organisational knowledge	Key learnings about an organisation's processes that build internal business knowledge.	9 instances from 5 cases
vi. Facilitate organisational benchmarking	Enhance the implementation of organisational benchmarks and best practice standards from process insights.	7 instances from 6 cases
Hybrid: impact achievable through the factors of innovation or learning (as described above).		**55 instances from 24 cases**
vii. Efficiency in operations	Running business operations at a shorter time with minimal rework rates and lower operational cost which may result in re-structuring and re-organising business functions or making the organisation adapt to changing business trends.	34 instances from 16 cases
viii. Expanding process mining capabilities to other parts of the organisation	Expanding the scope of their process mining projects based on satisfactory outcomes from process mining projects.	10 instances from 9 cases
ix. Organisational change catalyst	Provide the basis for effective change management initiatives within the organisation.	5 instances from 5 cases
x. Re-defined business reputation	Reshaping an existing external perception of an organisation	6 instances from 2 cases

4.1.1. Impact on the Process

The **Impact on the Process** category captured any impact that results in a direct modification or re-designing of the business process-after the process mining analysis.

Process optimisation was referred to in various ways, such as "reduced throughput times" (Case 4), the ability to modify some technical "process to be much more lean" (Case 51) and achieving "faster turnaround time with less time and effort" (Case 33). Likewise references to the impact of **Process standardisation** included enabling organisations to "align process to best practice" (Case 2) and ensuring "internal standardisation of workflow" (Cases 10 and 29). With **measurable and improved Key Performance Indicators (KPIs),** organisations experienced a "boost in KPIs" (Case 6), the creation of "improved KPIs for modified processes" (Cases 22, 38 and 48) and the ability to "monitor performance indicators" (Case 49). **Process automation** provided a "significant reduction in manual work" (Cases 25 and 37) with efficient processes automated through the introduction of other tools such as RPA, Machine Learning algorithms or a mobile application (Cases 2, 46 and 35). There was "increased automation of end-to-end" processes (Case 1), especially within the procurement process.

PM presented some organisations with **process audit opportunities**, such as "new perspectives for representing and auditing processes" (Case 11), become "more efficient in executing audits" (Case 24) and "follow up on audit recommendations" (Case 11). Consequently, global organisations with shared offshore services could perform remote centralised audits for their branches worldwide from a centralised point.

4.1.2. Customer impact

Customer impact captured any impact that directly improves the service provided to an organisation's customers.

PM enabled organisations such as Case 2 to attain **improved customer satisfaction** by implementing a global benchmarking to address "variation in customer support". Case 49 experienced "improved customer satisfaction through a clear visual understanding of the real process and the deviations". Finally, with faster processes, employees could "invest their freed-up time in offering high-quality service" to clients (Case 22).

Improved service delivery especially in the IT service management domain where retailers "no longer need to get frustrated about IT errors and can instead look forward to reduced solution times" (Case 35), achieve "quality, dependability and delivery reliability among our customers" (Case 25), or provide "more accurate and reliable information" (Case 29).

4.1.3. Financial impact

The **Financial impact** category captured any impact directly relating to cost savings or creating savings potentials in the organisation.

Most organisations "built operational steering capabilities" (Case 12) which directly translated into **operational cost savings**. "Handling time improvements" also led to over $20 million in efficiency gains (Case 2).

PM assisted in strategic decisions regarding **cost savings potentials** by "analysing facts and findings, allowing for business consequences by identifying what the issue is that requires improvement, what

would be the adequate solution and what savings potential can be reached by calculating the potential benefit" (Case 4). Also, "visibility of all process variants and the comparison of the As-Is with the To-Be process provides savings potentials and efficiency gains" (Case 8).

4.1.4. Impact on Innovation and Learning

The **Impact on Innovation and Learning** category captured any impact that generates knowledge within the organisation or creates a key transformation in the organisation's operations, for instance, *efficiency in operations* gained from re-structuring business functions to meet changing trends. These were based on broader insights (i.e., those that go beyond the boundaries of the mined process) applicable and adaptable across different parts of the organisation. Identified subcategories were grouped based on their ability to create a key transformation in the organisation (Innovation), generate knowledge (Learning) or a hybrid of these outcomes.

4.1.4.1. Innovation

PM results are useful for making **data-driven decisions** by providing "real facts to support better decisions" (Case 6) and "an efficient way to get insight of processes based on data" (Case 37). With such a "monitoring tool that allows data-based fast decisions" (Case 3), it facilitated the "debunking of anecdotal wisdom on how processes should be improved" (Case 48).

Introducing PM provided **enhanced analytics** capabilities, acting as a "door opener for advanced analytics" (Case 12). With such "increased analytical capacity of operational teams" (Case 6) and in some cases "expanded analytics across many sectors" (Case 7) some organisations saw the potential to "make transition from descriptive to prescriptive analytics" (Case 7).

PM, as a digital transformation catalyst, laid the **foundation for deploying new technology**. Some organisations were "able to establish a new digital steering solution" (Case 12) from PM as a powerful and flexible reporting solution. PM also facilitated "increase digitalisation by introducing Electronic Data Interchange (EDI)" (Case 4) and in some cases a "digital transformation from data analytics and data mining to PM" (Case 11). All of these called for a new way of thinking for improving processes.

In the order to cash (O2C) process in Case 34, large-scale process standardisation from PM provided **further automation opportunities** for the business process. Process optimisation also justified "further automation of various processes" (Case 34). With "reduced manual tasks" (Case 1) and "reduced manual activities" (Case 1), organisations were able to take advantage of such large-scale automation opportunities, especially for global processes. Such opportunities often introduced approaches, such as "new ways to automate billing" (Case 1), leading to shared knowledge and experience organisation wide.

4.1.4.2. Learning

PM provides key learning about an organisation's processes, which creates opportunity to **build organisational knowledge**, "collecting all kinds of process and product parameters throughout the entire production process" (Case 31) for "improved product design from knowledge gained" (Case 10), "accelerating the organisational learning cycle" (Case 10) and building "internal competence to build new process models in-house" (Case 12). Case 1 reported "knowledge sharing and experience among countries" globally. Case 31 reported it was also able to "side-scaled this knowledge to our factory in the UK" for performance improvement.

PM insights provided an increased understanding that **facilitated organisational benchmarking,** to "modify KPIs in ways that really optimise the output" (case 3) of business processes and enable "best practices to be developed and rolled out to other locations" (Case 25) of an organisation. With such advantages, organisations could focus on "the creation of a corporate-wide business process maturity framework" (Case 35).

4.1.4.3. Hybrid

PM also increased **efficiency in operations** such as "handling time improvements" (Case 2), "reduction of operational costs and time to corrective action" (Case 49), "reduction in rework rates" (Cases 3 and 4), "cutting factory lead time by half" (Case 31) and facilitating the "strengthening of internal control systems" (Case 11). Other organisations were able to "ship all standard orders on the same day" due to "reduction in delivery processing time" (Case 9). With such advantages, organisations such as Case 11 had the right "basis for establishing more efficient audits" as "many process audits could be carried out

centrally in the form of desktop audits". PM also influenced re-structuring activities; for instance, streamlining operations at Case 1 via the "consolidation of order management organisations into hubs" for specific global regions, and the "creation of three new order management hubs" globally. Case 3 also reported building business agility capabilities; with "process standardisation", "transparency" and "speed", PM became a key tool for enabling Case 3 to meet new challenges and make processes fit for the future.

Organisations were keen on **expanding PM capabilities to other parts of the organisation** based on satisfactory outcomes from PM pilot projects. This subcategory emerged during Phase 2 (Section 3.2.2) where many of the cases analysed were proof of concepts in organisations that had just been introduced to PM, whereas most of the cases analysed in Phase 1 had a wider scope and had been running for a minimum of one year. The initial success of the test projects became the main motivation to expand the use of PM to other processes in the organisation. For instance, Case 46 "requested further analyses such as the call centre process analysis and the payment process analysis", while at Case 53, a Dutch utility service provider, "the analysis of the purchasing process was so successful that they extended PM to other areas of the business" This was also reported for cases in the public sector as Case 52 confirmed that "the success of this initial project has spurred the Council to look at other departments that could benefit from Perceptive Process."

PM insights are an **organisational change catalyst,** enabling organisations to perform fast verification and follow-up of process changes which facilitated "effective change management" (Case 49) and fostered a "continuous improvement culture" (Cases 2 and 7), ensuring that organisational change decisions do not negatively impact organisational KPIs. With such flexibility, organisations have built an "increased capacity to deal with business changes" (Case 6) and, in global organisations, assured "process performance during organisational change" (Case 1).

The introduction of PM may also **re-define existing business reputation,** causing a "reshaped perception of internal clients and stakeholders" (Case 12). It positioned Case 12 as a "well-recognised partner in terms of innovation and optimisation" resulting in "higher quality job applications". Case 13

reported that "the work environment has improved, and the efforts of the employees are now much more valued than before".

4.2. Relationships between identified PM impacts

Direct and *indirect* relationships were identified to provide a richer understanding of the PM impacts. Frazier *et al*. (2004) explain that a direct relationship captures how one factor can influence another (implying a causal relationship). An indirect relationship is a relationship whose outcomes are influenced by moderating or mediating variables (while moderating variables "*alter the strength or direction of a relationship between a predictor and an outcome*", mediating variables "*are the mechanism through which a predictor influences an outcome*" (Frazier *et al*., 2004, p.116)). Figure 2 depicts these identified relationships as propositions (indicated as **P***n*).

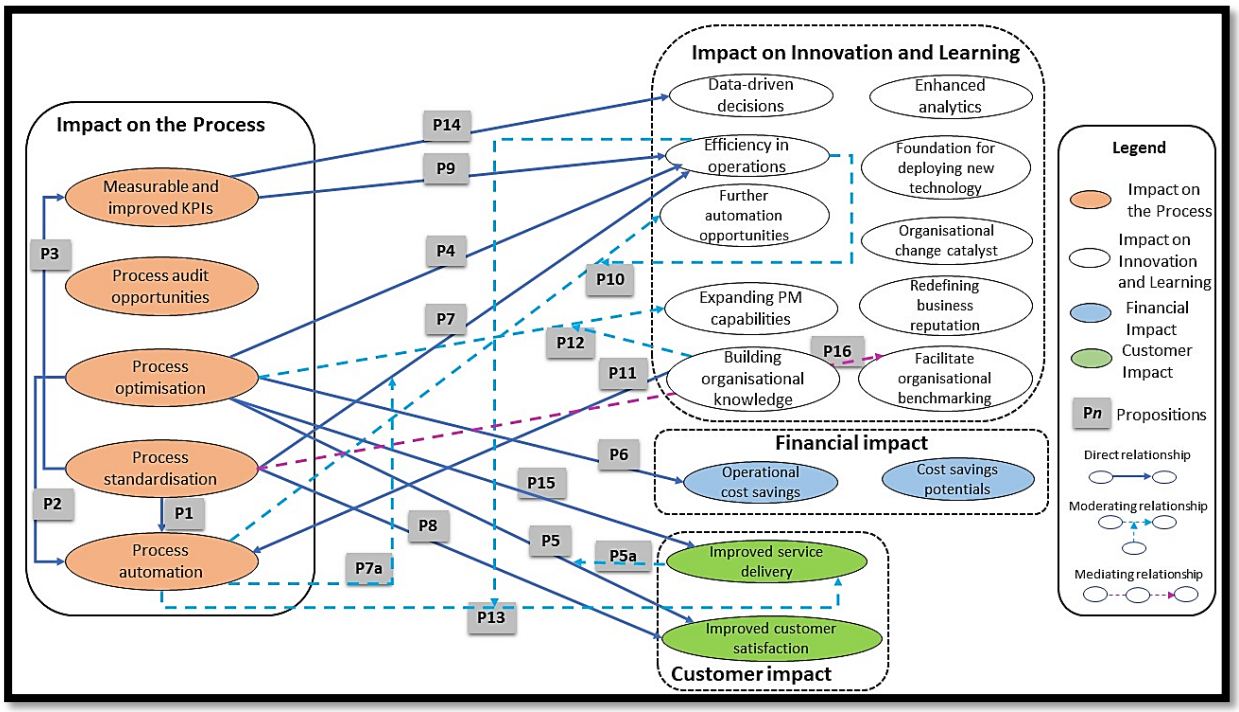

Figure 2: PM impacts, with indicative relationships.

Most of the identified relationships in Figure 2 illustrate how PM impact often originated in *impact on the process* and then led directly or indirectly to the other categories of impact (i.e., *innovation and learning*, *financial* or *customer* impact categories). This is aligned to previous research (e.g., Mooney *et al*., 1996; Melville *et al*., 2004). Such a process-oriented approach to value realisation identifies the

significance of information technology to reengineer business processes (Mooney *et al*., 1996), and process impacts as the first level of business value, followed by organisational impact (Melville *et al*., 2004; Tallon *et al*., 2000). Part D of the Appendix presents supporting sample evidence for all relationships identified.

The only relationships identified between subcategories within the same category relate to the *Impact on the process*, described in Section 4.2.1. The relationships between *Impact on the process* and other categories are described in Section 4.2.2.

4.2.1. Relationships within the Impact on the process category

At Case 2, **process standardisation** had a direct influence on **process automation** [**P1**]. With the ability to measure metrices such as Average Handling Time (AHT), similar processes between agents, sites and cities could now be compared and aligned to best practices for automation through RPA.

P**rocess optimisation** directly influenced **process automation** [**P2**]**.** Through real-time process monitoring, for example, Case 25 was able to attain notable improvements such as rebuilding individual product lines, and realising shorter production times, leading to the automation of individual manual activities.

Process standardisation resulted in **measurable and improved KPIs** [**P3**]. For example, due to harmonisation of processes at Case 38, important indicators such as process performance indicators (PPIs) and key performance indicators (KPIs) were implemented to provide a solid ground for measuring process effectiveness.

4.2.2. Relationships between Impact on the process and other categories

Process optimisation resulted in **efficiency in operations** [**P4**]. With process mining insights, organisations such as Case 16 were able to make significant improvements to their student admission process, leading to "better practices and higher levels of efficiency". Case 30 optimised its business processes by tracking down and eliminating bottlenecks, manual procedures and process inefficiencies resulting in a systematic improvement of their operations.

Process optimisation also ultimately impacted **improved customer satisfaction** [**P5**]. Organisations such as Case 39 found that even after process optimisation, the data provided surprising discoveries that had the potential to impact process performance and ultimately customer satisfaction. Case 49, an industrial measurement organisation, also realised "improved customer satisfaction through clear visual understanding of the real process and the deviations, resulting in process optimisation".

Following the above, it was discovered that **Improved service delivery** moderated how **process optimisation** led to **improved customer satisfaction [P5a]**. Within six months of PM implementation at Case 22, there was 30% improvement in throughput time in the retail process allowing employees to invest their freed-up time in offering high-quality service, thereby boosting customer satisfaction.

Some organisations also reported a direct relationship between **process optimisation** and **operational cost savings** [**P6**]. Case 35 confirmed the ability of PM to provide "scalable on-demand visualisation of processes to fully exploit the hidden potential of the ticket data" for cost efficiency.

Process standardisation resulted in **efficiency in operations [P7]**. **Process standardisation** also resulted in **improved customer satisfaction [P8].** Through process harmonisation, Case 2 was able to understand the respective process variations and target multi-million dollar efficiency gains. The implementation of process benchmarking techniques globally also increased customer support, resulting in increased customer satisfaction at Case 2.

Also, **process automation** moderated how **process standardisation** resulted in **efficiency in operations [P7a]**. After stabilising their business processes, Case 26 could identify areas for process automation as a means of further improving effectiveness and efficiency.

Measurable and improved KPIs impacted the rate of an organisation's **efficiency in operations [P9].** At Case 1, the global implementation of the digital fit rate (a new KPI which counts the number of manual touch points required to process a customer order divided by total sales orders received) to its O2C process resulted in a reduction of this KPI by 1.0 globally, which translated into efficiency in O2C operations.

Process automation was a precursor for **further automation opportunities** and was moderated by **efficiency in operations [P10]**. By automating their order entry process, Case 1 had efficient electronic orders and improved end-to-end (e2e) processes between clients, regional companies, and distribution centres. This provided the opportunity to explore further automation opportunities of back-to-back purchase orders within their regional company and distribution centres.

Building of organisational knowledge further supported **process automation [P11].** At Case 1, the knowledge and experiences from regional and distribution centres in other countries paved the way for the introduction of new ways of automating the billing process in other branches of the organisation (Case 1). **Building organisational knowledge** moderated how **process optimisation** provided opportunities for **expanding PM to other parts of an organisation [P12]**. After addressing the cancer diagnostics process, the IT department of Case 19 built organisational knowledge from PM application which provided the needed confidence to embark on PM initiatives in their cardiology, radiology, and emergency departments.

Efficiency in operations moderated how **process automation** influenced **improved service delivery [P13].** Case 1 gained confidence to pursue a strategic goal of re-structuring the order management centres into regional hubs across different countries (efficiency in operations) after improvements from process automation which enabled them to better serve customers globally.

The introduction of **measurable and improved KPIs** at Case 6 provided the needed benchmarking opportunities for understanding organisational processes. As a result, they could make **data-driven decisions [P14]** for process improvement initiatives that insights from business intelligence solutions alone could not accomplish. **Process optimisation** led to **improved service delivery [P15].** Case 35 realised an improved service delivery to their retailers when existing IT errors and solution times were identified and resolved with the aid of PM. **Building organisational knowledge** of comparing similar processes mediated the relationship between **process standardisation** and **organisational benchmarking [P16].** With the knowledge derived from directly comparing the production of similar parts at different plant locations, Case 25 could compare where weak points exist in each plant and

identify ideal running times. This enabled the ability to develop and transfer best practices to other locations.

5. Discussion

Despite significant demand, research on PM impacts is scarce. PM success studies (e.g., Mans *et al*., 2013; Decker, 2019) attest to the significance of PM impacts but focus on success factors and give very little guidance on how to conceptualise PM impacts. This study has addressed this problem, deriving a PM Impacts Framework through the analysis of 62 case reports of contemporary PM initiatives, that represent a wide cross-section of PM contexts. This framework conceptualises four key areas of impact: *impact on the process, impact on innovation and learning, financial impact,* and *customer impact, and* 19 specific impacts within these areas. This study is the first to explore the nature of relationships (direct and indirect relationships) between these impacts, and thus extends the understanding of the nature of the impacts.

Our study has several implications for *theory* and *practice*. Firstly, it makes **theoretical contributions** to the PM domain by *introducing new constructs* and *better conceptualising existing constructs* (Barki, 2008) pertaining to PM impacts, carefully aligned with the theory-building concepts of discovery, description, mapping, and relationship building as described by Handfield and Melnyk (1998). Domain-specific classifications for PM impacts are derived and described in context, such as is seen in related fields such as BPM (eg: Poelmans *et al*., 2013). Our study supports theoretical context-extensions (Berthon *et al*., 2002) by applying the Balanced Scorecard as a classification scheme to categorise PM impacts into *impact on the process, impact on innovation and learning*, *customer impact* and *financial impact* and identifying interrelationships that exists between subcategories.

This study further confirms prior work such as Mooney *et al*. (1996) and Kohli and Grover (2008), that depict how impact realisation is multi-staged; occurring first at the process level, and subsequently translating to organisational level impacts. In our analysis of the relationships between PM impacts (see Section 4.2), we point to how *impact on the process* influences the attainment of organisational level impacts (innovation and learning, financial, and customer impacts) in many cases.

The study also **contributes to practice** as follows. There is a lack of value assessment tools to make a PM business case with senior executives (Grisold *et al*., 2020), and there are few guiding frameworks to justify the significance of PM as a technology investment and motivate its continued use (Mans *et al*., 2013). A sound conceptual understanding of the impacts of PM is needed to enable better planning (i.e., to derive PM business cases and to plan for PM benefits realisation) and assessment of PM efforts.

Process managers can also apply our framework during PM initiatives as a gauging mechanism to understand what impact options are available to their organisation and how *impacts on the process* are likely to trigger organisational-level impacts. Existing PM users could rely on this framework to support their benefit realisation plans. The mappings of the categories to the data points (see Appendix Part C) provide vivid examples on how to apply the framework as a point of reference when planning for or reporting PM success.

This study has **limitations** in its reliance on published case reports. Nonetheless, these case reports collectively provide insights into the outcomes of process mining initiatives in organisations, hence a valuable resource to commence a research program on PM impact. Being a qualitative study, the risk of researcher bias also pertains. We, therefore, suggest **future research** that can build on this work and address these limitations. First, we propose to conduct a series of in-depth case studies to gain rich contextual insights from multiple stakeholders such as PM analysts, process domain experts and PM consultants, to further confirm the elements of our PM Impacts Framework, to validate the relationships noted between them and to assess which impact types are more relevant across different stakeholder groups and case contexts. Second, a more granular conceptualisation (especially of the subcategories) is warranted. Future research could explore these categories and subcategories in specific industry contexts to provide a more detailed understanding of their interrelationships through in-depth case studies or surveys. Third, the PM Impacts Framework can also be converted to an open-source quantitative tool that can be applied by practitioners to assess and report on their PM project successes and failures and would be complemented with actionable guidelines for its implementation and use.

6. Conclusion

As the PM market continues to grow and more organisations express interest in adopting PM, understanding its impact on the organisation is essential. Prior studies have indicated the significance of PM impact but attempts to conceptualise PM impact to date are based on anecdotal evidence from a single stakeholder perspective. This study investigates PM impact from the viewpoint of published success stories. Identification of the key categories of PM impact, is based on a rigorous qualitative analysis of 62 published cases reporting the benefits of PM.

The proposed PM Impacts Framework categorises the PM impacts into four key categories: *impact on the process*, *impact on innovation and learning*, *customer impact* and *financial impact*. Specific subcategories are identified for each of these. By investigating pertinent interrelationships, we explain how *impact on the process* directly or indirectly influences impacts in the other three categories. *Impact on the process* occurs through organisations engaging in one or more of the following: *process optimisation, process standardisation, measurable and improved KPIs, process automation* and/or *process audit opportunities*. *Impact on innovation and learning*, *customer* and *financial impacts* also influence financial and non-financial aspects of the organisation.

This framework will assist process stakeholders and PM consultants to understand the nature and value of the impact of PM in context, for proper planning, and reporting the success of PM initiatives to senior executives.

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Appendix: Supplementary Material

Supplementary material for this article is available online at https://tinyurl.com/3227y8ps It consists of the following parts:

Part A – an overview of the 62 case reports analysed,

Part B – coding rule book,

Part C – example quotes supporting the PM impact categories of our proposed framework,

Part D – case evidence supporting the identified interrelationships of the PM impacts,

PART E – further details to elaborate coding journey.

E1 – In-vivo and axial coding.

E2 – Matrix Queries for identifying possible relationships.