The role of information technology in performance measurement systems: case study in a synthetic rubber factory

Fernanda Tercero¹, Luiz Felipe Scavarda¹, Matheus Allgaier¹, ²

Abstract: Monitoring the performance and controlling the evolution of suppliers ensure a better balance between the service contracted and effectively provided by the carriers, which sets up a quality logistics management profile based on the control of supplier indicators for the generation of periodic performance evaluations. The literature reinforces the role of information technology (IT) for the success of a performance measurement system (PMS). However, even though a sophisticated IT solution offers a quick collection, analysis, and dissemination of data, it can result in additional costs for the organizations during implementation and usage stages. This paper’s goal is to analyse the role of IT in PMS, towards verifying if sophisticated IT is necessary in consolidating the PMS or if it is possible to create a successful PMS with few IT resources. The research presents a case study of a Latin American subsidiary of a multinational in the chemical sector, which implemented a successful PMS for its logistic and supply chain department. Research findings indicate that even with no use of costly and sophisticated IT, the subsidiary has achieved excellence and global recognition within the multinational organization. Research findings indicate that it is feasible to improve planning and monitoring in the supply chain, without using costly and advanced IT. Managers can take benefit of the case offered herein with insights and means of seeking to improve logistics management in a less costly manner and obtaining competitive advantage for companies.

Keywords: Performance Indicators, Supply Chain, Logistics;

1 Introduction

In the late 1970s, Performance measurement systems were adopted by some authors as a result of their dissatisfaction towards traditional accounting systems (NUDURUPATI et al., 2011). Modern approach to supply chain management and logistics management includes management strategies, which should not only observe cost efficiencies, but also analyse, among others, physical, ecological, and historical factors, which equally hamper the process of physical distribution (MILOS et al., 2018). Thereby all entities along the supply chain are challenged to adopt new business models, techniques, and processes to enable a smooth transition into a digitalized supply chain management (KERSTEN et al., 2019; SCAVARDA et al., 2019; CAIADO et al., 2021). In the context of resilience, performance measurement systems (PMSs) have become an important subject for scholars and practitioners since the end of the 1980s (GUTIERREZ et al., 2015). Since then, the literature pertaining to this subject has seen increased relevance on studies about PMS (HALD & MOURITSEN, 2018; NUDURUPATI et al., 2011). An effective PMS should be able to

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monitor past performance and reinforce new plans to improve future performance, providing a balanced accounting of the business, showing how results are related to decisions, preventing the inclusion of conflicting measures, directly influencing management strategies, and harmonizing with the organizational culture so that it also provides reward systems and data for external comparison (NEELY et al., 1996; GUTIERREZ et al., 2015).

The decision of putting a large variety of finished products on the global market demands great abilities and skills to control a large amount of different and equally demanding technologies (PERONA & MIRAGLIOTTA, 2004). Within the modernizing supply chain management, responsiveness in the supply chain management became a focal area due to the trend of many markets to become volatile and difficult to predict (CHRISTOPHER & HOLWEG, 2011; CERYNO et al., 2013; FERREIRA et al., 2018). This encouraged the development of performance measurement applications and information technology (NUDURUPATI et al., 2011), which is of primary importance to configure and implement any PMS (NUDURUPATI et al., 2011; MAESTRINI et al., 2017). Regarding performance measurement, key performance indicators (KPIs) emerge as an fundamental management tool for solving the volatility and the difficulty issues, indicating the effectiveness and/or efficiency of a part or whole of the process or system against a given norm/target or plan (FORTUIN, 1988). Real time KPIs for production and logistics may become the structure for a soft and adaptive production systems (HABE et al., 2019). Each performance indicator describes a different aspect of supply chain performance. (LI & ZOBEL, 2020).

Many authors agree that the rate of change, especially in technology, has been greatly accelerated since the 1950s (BOURNE et al., 2003). The introduction of powerful technological tools has often led companies to focus their attention on new technology (SERAFEIMIDIS & SMITHSON, 2000; GARENGO et al., 2007) and use of IT tools to help people perform all tasks related to information processing and management (HAAG et al., 2002; GARENGO et al., 2007), emphasizing that IT plays a role in data capture, in data analysis and presentation. which justify the accelerated increase in demand for IT systems recently (NEELY, 1999). Supply Chain Performance Measurement Systems are, therefore experiencing a new business phase due to new technologies that allow the collecting, integrating, and sharing of information among multiple supply chain partners (MAESTRINI et al., 2017).

As limitations of traditional financial measures have already been known, there are companies interested in PMS and the power of IT is one of the main reasons suggested by evidences. Consequently, the final driver in the PMS is unquestionably the IT (NEELY, 1999) and PMS was developed in response to the developments of IT (NUDURUPATI et al., 2011). One of the critical factors for PMS implementation is the Management Information Systems (MIS) (HAAG et al., 2002; GARENGO et al., 2007) because also uses IT tools as essential role on the flow of information (NUDURUPATI et al., 2011), not only in data capture, but also in data analysis and presentation (NEELY, 1999). If the current MIS cannot support the PMS changes by automatically collecting, processing and reporting the data due to inflexible systems (KENNERLY & NEELY, 2000), or fragmented IT infrastructure (TAYLOR & TAYLOR, 2013), then too much effort is required to perform these tasks that can threaten the success of the PMS change (BOURNE et al., 2002; BRAZ et al., 2011; GUTIERREZ et al., 2015), bearing in mind that with no IT support, the PMS became more complex and less flexible.

Within this context, this paper addresses a research-practice gap in academia by showing that even though there are many recognized advantages in the literature regarding the large-scale use of IT, making it essential in the view of most authors, it can lead to higher operational costs. Moreover, this large-scale use can lead to difficulties in reviewing and updating the PMS, as it relates the complexity inherent to changes in IT to implement changes in procedures to calculate performance measures (BRAZ et al., 2011). In addition to these difficulties, there is a possible shortage of budget on the part of companies to increase

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the use of IT. This scenario leads to the following research question: “is it possible to have a successful
PMS with few IT resources?”. To address this research question, the goal of this paper is to analyse the role
of IT in the PMS of a Latin American subsidiary of a multinational in the chemical sector, which
implemented a successful PMS for its logistics operations.

This paper is organized in five section being this first one the introduction. Next the paper describes the
theoretical background and the adopted research method. Section four offers empirical evidences and
discussions on the research findings. Finally, the paper provides in its last section the authors’ final remarks
and conclusions, together with suggestions of future research.

2 Theoretical Foundation

Innovation, globalization of markets and increasingly demanding customers are trends manufacturing
companies cannot escape (PERONA & MIRAGLIOTTA, 2004). Due to competitive environments and
high rates of technological current changes is evident the power of IT as the main driver in the PMS
revolution (WAGNER & JOHNSON, 2004). In today’s complex business world, organizations must be
able to learn how to survive with endless changes in order to be prosperous. Consequently, a dynamic PMS
might reflect innovation in the internal and external environment (KENNERLEY & NEELY, 2002) because
some authors assumes that a PMS without IT will certainly be temporary (BITITCI et al..2012).

Neely et al. (1996) define performance as the efficiency and effectiveness of actions within a business
context. Performance measurement is the process of quantifying efficiency and effectiveness of actions of
part or of an entire process or a system in relation to a pattern or target (FORTUIN, 1988; NEELY et al.,
1996; BRAZ et al., 2011). PMS is a subject that has seen an increase in interest by both academics and
practitioners (NEELY et al., 1996; MAESTRINI et al, 2017) because they are composed of performance
indicators which are essential in the planning and strategic control of the company as an object of interest
between academics and researchers (FERNANDEZ et al, 2012). The PMS can be considered a
measurement system when it is incorporated into the structure of data banks and the definition of
organizational steps to measure performance as complete and consistent form (FORTUIN, 1988; NEELY
et al., 1996; FERNANDEZ et al, 2012). In addition, the results indicate that the choice of performance
indicators by which resilience is critical for interpreting the supply chain network resilience (LI & ZOBEL,
2020) as long as these are a means to compare actual results with targets, measuring the extension of
possible deviations (FORTUIN, 1988). That is why, supplier evaluation is important for organizations due
to the predominant role that suppliers comply with the dynamics of supply chains and the strategic
importance of purchasing functions have as a result of the outsourcing of processes that are not part of
the company's know-how (TATE & VAN DER VALK, 2008; FERNANDEZ et al, 2012). In this context, the
supplier PMS aim to continuously improve the performance of the purchasing company by availing the
capabilities of its suppliers (WAGNER et al, 2004; FERNANDEZ et al, 2012). The contemporary PMS
combines financial, strategic, and operational aspects of business to identify strategic performance
dimensions (HALL, 2008; FRANCO-SANTOS et al., 2012).

Information systems are important enablers of PMSs (TAYLOR & TAYLOR, 2013) and might be
functional on contemporary performance measurement which comprises the use of financial as well as non-
financial performance measures linked to the organization’s business strategy (FRANCO-SANTOS et al,
This may explain why many organizations are investing heavily in the development and maintenance of PMS (FRANCO-SANTOS et al., 2012) and the enthusiasm of the most companies to drive for “total quality control” enhanced the for performance indicators (FORTUIN, 1988). Furthermore, current supply chain management practice has sought to create dynamic flexibility, allowing firms to cope with certain shifts in demand and technology, but only within the set structure of their existing supply chain design (CHRISTOPHER & HOLWEG, 2011). The flexibility to the environment helps organizations meet their current needs, without losing the ability to produce, hence, it can be considered a significant factor in generating success and competitive advantages, whilst bringing significant challenges for organizations (SEIDIAGHLABADI et al., 2019).

The power of IT is considered one of the main reasons why PMS is placed high on the agenda (NEELY, 1999). Digital work developments in logistics and supply chain management encompass multitude factors, concepts and technologies (KERSTEN et al., 2019), putting technological change as a decisive factor in the environment of firms in most industries and countries (CONCEIÇÃO, 2000), where IT tools may also be facilitators, but they do not seem to be the primary process drivers (GRIMSON & PYKE, 2007).

Every day, logistics generates a vast amount of data, which is mainly generated by monitoring enormous flows of goods and highlighting the real-time data as an important instrument for visualizing events immediately (KERSTEN et al. 2019). Re-cent developments such as Internet of Things (IoT), Industry 4.0, Artificial Intelligence (AI) and other digital technologies are transforming Supply Chains (CAIADO et al., 2021), allowing them to operate based on autonomous decisions analyzing collected data in real-time modus (FELDT et al., 2019). When applied to transportation logistics, information technology is utilized in the vehicle tracking system used by carriers to monitor fleet performance indicators. Transport companies need to focus on a small list of key performance indicators (KPIs) that are critical to managing the physical distribution process and that will ensure the financial sustainability of companies (MILOS et al., 2018). This reinforces the perspective that as long as IT has improved, there have been attempts to impose technological solutions without addressing business processes (GRIMSON & PYKE, 2007) and to press quality improvements with optimize on cost and technology, which is demanded in highly competitive environments with high rates of technological changes (WAGNER et al., 2004).

Logistics and transportation systems as part of logistics need to be consistent with the products they support, because customers tend to make no distinction be-tween a product and the distribution system that supplies (ECKHARDT & RANTALA, 2012). In this regard, this study was carried out with an exclusive focus on road transport, which within the Brazilian transport matrix corresponds to 65% of the total goods transported in Brazil (MOREIRA et al., 2018). Although the most of PMS practices are supported by information technology, there is, indeed, some evidence of performance-measurement systems without information technology support are presumed to be momentary (BITITCI et al., 2012).

3 Research Methodology

High-quality suppliers are fundamental for the success of organization. Adopting an outsourcing strategy in organizations reinforce and increase the importance of the supplier evaluation process (PURDY & SAFAYENI, 2000). With the evolution of the concept of quality, the continuous improvement increases as target conducted by powerful IT developments and innovation in IT build a heavy relationship between a PMS and a company’s information system (GARENGO et al., 2005). PMS are experiencing a new business practices due to new technologies that allow the collecting, integrating, and sharing of information among multiple supply chain partners (MAESTRINI et al., 2017). This paper offers the findings of an exploratory research, which analyzes a real case scenario to demonstrate an example abnormal. While some case-based

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studies follow (MAESTRINI et al., 2017) the strong recognition of essential IT utility to create a PMS, this paper describes and demonstrates another possibility to create a PMS using simple IT tools and with spreadsheet may be sufficient for a successful PMS. Adopting a case study research (YIN, 2009) in a synthetic rubber factory in Brazil, this paper proves a concrete possibility to create a PMS without using IT. In order to mitigate the bias in favor of the IT uses on PMS, this paper emphasizes on data triangulation, precise documentation of the data base and maintaining the chain of evidence which provides validity in reconstructing the study from the research question to the conclusions (YIN, 2009).

This method was chosen to present the findings from a company which uses an efficient option to create PMS as a strategic decision. Through the project implementation, with an international recognition inside the organization, the suppliers’ performance is available for the company access and also add value throughout its supply chain, without using sophisticated IT which has benefit factors as operational efficiency, accuracy, visibility and security (ECKHARDTA & RANTALA, 2012). The mentioned sophisticated IT must guarantee the collection of real-time data relies on good technology. As an example, this kind of IT can develop a business performance measurement (BPM) systems as an appropriate system which might be designed for collecting, analyzing, and reporting the data efficiently. In this way it will be possible to get critical insights to start an automatic and efficient data review process (FRANCO-SANTOS & BOURNE, 2005).

Initially, the validation of the generated data occurs from the registration of details generated by evaluated suppliers obtained in the ERP (enterprise resource planning). Once generated, all information is copied by logistics department to a matrix spreadsheet that will serve as a database for all handling of the PMS and will indicate percentages of the analysis of each supplier. In parallel, spreadsheets are made for each supplier individually, with created formulas which are based on the percentage criteria adopted for each KPI. Thus, a percentage of each KPI in the analyzed month is generated and, finally, a final score will be composed to direct to the final classification assigned to the carrier, according to the metrics previously defined in the Scoring and Ranking Criteria (see Table 1 - Scoring and Ranking Criteria).

### Tab. 1 Scoring Criteria

<table>
<thead>
<tr>
<th>Evaluated Items</th>
<th>Criterion</th>
<th>Punctuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident</td>
<td>No occurrences</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>&gt; 0</td>
<td>0</td>
</tr>
<tr>
<td>Customers</td>
<td>Over 10% of total shipping</td>
<td>0</td>
</tr>
<tr>
<td>Complaints</td>
<td>Up to 10% of total shipping</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>No complaints</td>
<td>100</td>
</tr>
<tr>
<td>Plant</td>
<td>Over 10% of total shipping</td>
<td>0</td>
</tr>
<tr>
<td>Complaints</td>
<td>Up to 10% of total shipping</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>No complaints</td>
<td>100</td>
</tr>
<tr>
<td>Pick Up On Time</td>
<td>Below 70% of total shipping</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Between 71 to 80% of total shipping</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Between 81 to 90% of the total shipment</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Between 91 to 95% of the total shipment</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Between 96 to 99% of the total shipment</td>
<td>95</td>
</tr>
</tbody>
</table>

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A sum might be made for each of the analyzed KPIs in each month and, thus, the classification of each supplier is obtained following a score scale of the quarterly ranking established by the organization (tables 4 and 5).

<table>
<thead>
<tr>
<th>Delivery On Time</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% of the total shipment</td>
<td>100</td>
</tr>
<tr>
<td>Below 70% of total shipping</td>
<td>0</td>
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<tr>
<td>Between 71 to 80% of total shipping</td>
<td>30</td>
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<td>Between 81 to 90% of the total shipment</td>
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<td>Between 91 to 95% of the total shipment</td>
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<td>Between 96 to 99% of the total shipment</td>
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<tr>
<td>100% of the total shipment</td>
<td>100</td>
</tr>
<tr>
<td>Over 30% of total shipping</td>
<td>0</td>
</tr>
<tr>
<td>Between 31 to 40% of the total shipment</td>
<td>20</td>
</tr>
<tr>
<td>Between 21 and 29% of the total shipment</td>
<td>80</td>
</tr>
<tr>
<td>Between 11 and 20% of the total shipment</td>
<td>85</td>
</tr>
<tr>
<td>Between 6 and 10% of total shipping</td>
<td>90</td>
</tr>
<tr>
<td>Between 0.1 to 5% of total shipping</td>
<td>95</td>
</tr>
<tr>
<td>100% of the total shipment</td>
<td>100</td>
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<table>
<thead>
<tr>
<th>Delivery date registered</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>AA (100%)</td>
<td></td>
</tr>
<tr>
<td>A (95%-99%)</td>
<td></td>
</tr>
<tr>
<td>B (90% - 94%)</td>
<td></td>
</tr>
<tr>
<td>C (80%-89%)</td>
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<td>D (0-79%)</td>
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</table>

**Source:** Provided by the company analyzed in the case study (2020).

The exploratory research was carried out using qualitative data. An in-depth approach to the context analyzed was promoted through four semi-structured inter-views carried out with significant stakeholders of the PMS: two were conducted with managers from the logistics department and the other two with members of the operational team. The interviews were guided on three sets of questions. The first regarded the need of IT in the PMS. The second block concerned to how IT could help the PMS. Finally, the last block of questions focused on the negative impacts on the PMS if IT is not used. Triangulation was done not only by comparing the answers among the interviewees, but also by considering the analysis of internal documents of the company and accessing the PMS itself by one of the authors of this paper (Please see
Whenever a contradictory finding was revealed, the researchers went back to the interviewees to check the reasons and find an explanation.

![Diagram of Data Triangulation](image)

**Fig. 2 Data triangulation**

### 4 Results and Discussions

The origin of the Supplier PMS’s creation on the mentioned company was based on an initial project of the organization, which sought to obtain reports directly from the “Enterprise Resource Planning” (ERP), through the generation of consolidated information regarding performance evaluation of road transport providers. Since the studied company is active in the manufacture of elastomers and fits as one of the segments that make up the activities of the chemical industry, safety is crucial to guide and conduct employees and visitors behavior, which always has been perpetuated through investments in IT systems and receiving the financial support of management all times in order to spread this concern and responsibility as part of the organizational culture.

As it was removed from this company guideline, the initial attempt to implement a 100% automatic supplier PMS was not approved by management due to the high financial cost. Then, the company manager sought, using existing spreadsheets, tools to operationalize the process of evaluating supplier monthly performances. Therefore, in 2017, the organization's logistics department made it possible to adopt a model for measuring performance indicators of road transport suppliers without the use of sophisticated information technology resources that endure until today. Through the use of interconnected spreadsheets, it was possible to apply monthly scores based in metrics pre-applied by the organization for the performance of road transport suppliers according to six previously applied indicators: Transport incident, Customers

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Customer Complaints, Site Complaints, On-time pick-ups, On-time Deliveries and Number of shipments of confirmation of delivery data registered in the system. The described model was consolidated in this organization and works to this day as the main management tool and with recognition from the “Chief Executive Officer” (CEO) of Brazil and the headquarters located in Germany. Initially, the system was implemented in the 3 plants installed in Brazil and, due to its success and recognition by the board, its application was replicated in the company’s 11 plants worldwide, as a result of the recognition of its efficiency when used in guidance in decision-making by the main stakeholders active in contracting road freight.

Besides that, Figure 2 shows how with PMS there is a clear evolution in performances, which explains an increase on the final performance of suppliers. It means that with feedback meetings, some problems on their performance are recognized and described, enabling suppliers to improve: plan, do, control and act, (PDCA). An important period to be highlighted as an outlier is Q2-18 when Brazil had the truckers’ strike that occurred throughout the country paralyzing road transport in May of 2018, with highway blocks in 24 states and the Federal District. It caused shortage of various products and medicines around the country leading many cities to the situation of public calamity and others decreed a state of emergency.

It was unanimous among the interviewees that the perception that IT was necessary in the PMS, to customize the information and to ensure better maintenance of the generated data. As the way IT should be used in the PMS, opinions were divided between the views of managers and operational staff. The first identified that the use of IT should be implemented to improve the maintenance of data generated and seek the standardization of the whole process, from the database to the generation of the final qualification of a supplier’s performance. With a different view, the operational staff believe that IT should help with PMS by bringing optimization and agility.

On the presented study, with collected data, it was found that the registration of each of the transport phases (since the request for availability until the delivery of the product to the final customer) occurs through the date and time of load and delivery information. This data gathering comprises the preparation, consolidation, and dissemination of data for use in other phases of the process, primarily performed automatically by IT systems (WAGNER et al., 2014). At the end of the month, the ERP processes this information and synthesizes it in an electronic spreadsheet that works as a database for the manual performance analysis of each provider.

The management information systems (MIS) are critical to the success of PMS implementation (GARENGO et al., 2007; NUDURUPATI et al., 2011; GUTIERREZ et al., 2015), particularly in data
collection, analysis, presentation and dissemination (NEELY, 1999; GUTIERREZ et al., 2015). Through electronic spreadsheets and based on the establishment of metrics, final performance analyzes are generated for each carrier based on the final percentage obtained by each one. Thus, the lack of information technology is no longer an impediment to the adoption of an effective performance measurement system, because with the triangulation of collected data in the ERP, the treatment of these data in electronic spreadsheets and the final qualification based on in pre-defined metrics is possible, classifying the performance of the evaluated carriers.

Literature has shown that better logistics performance is strongly associated with trade expansion, export diversification, ability to attract foreign direct investments, and economic growth (FARIA et al., 2015). However, this company observed the possibility of improving its logistics management through better control of the suppliers' performance, allowing the creation of competitive advantage for its final product.

5 Conclusion

In order to approach the use of IT in a different way, this paper offers a case study in which it is possible to analyze an efficient PMS implementation with a methodology based mainly on electronic spreadsheets, avoiding high investments associated to sophisticated ITs.

Research findings corroborate the perception that not all organizations need a high level of IT, as the right level of maturity for this dimension may vary (GRIMSON & PYKE, 2007, MENDES et al., 2016). Therefore, managers need to carefully balance incremental and investment costs (WAGNER et al., 2014). This can indicate that it can be context dependent. Additional research should embrace the role of IT in PMS from the contingency theory view (SOUZA AND VOSS, 2008; THOMÉ et al., 2014).

Future research should also address the limitations of the presented study because as it was a case study which carried out in a single company, this study brings difficulties of generalization and prevents an analysis conducting of different obtained results with the lack of the use of IT for the realization of PMS.

As negative impacts on the PMS if sophisticated IT is not used, the interviewed manager recognized that, in this way, a great effort and a much time are requested by all professionals because this process is time-consuming and error-prone on several levels. In addition, the large amount of data involved made it difficult for planners to investigate and analyze inconsistencies and to identify the least costly and most profitable operations plan (TASKIN et al., 2015).

Although the exposed position, this paper contributes to the literature in PMS, bringing to managers the real possibility of implementing PMS successfully without high IT investments, showing that the use of sophisticated IT is not essential to measure the supplier performance.

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6 References

Please use Harvard style with a list of references sorted alphabetically as it is presented below. Please ensure the Harvard format is used (author, year) throughout the paper. Use the “References” style.


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