

Data value creation during disruptive events

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Abstract

In medium-sized firms, factors such as senior management involvement, organizational culture, and preferred organizational learning capabilities significantly influence data value creation. These factors are dynamic and evolve in response to adverse external conditions. This comparative study investigates two Canadian medium-sized enterprises in the electronic manufacturing sector that experienced significant supply chain disruptions during and post the COVID-19 pandemic. Initial interviews were conducted with executives in 2017, pre-pandemic, and follow-up interviews were carried out in 2023 to understand the influence of their chosen organizational learning approach on data value creation and resilience in their data-driven transformation. Findings suggest that exploitation organizational learning capabilities safeguard a firm's ability to sustain operational and strategic data value creation during disruptions. Conversely, exploration organizational learning capabilities facilitate an increase in strategic data value creation during the recovery phase but has less impact on operational data value creation. Therefore, while there is a connection between data capabilities and data value creation, this link may not be taken for granted during periods of significant supply chain disruptions. Incorporating organizational learning capabilities into the study of value creation trajectories over time enhances our understanding of this process.

Keywords

Ambidexterity, exploitation, exploration, supply chain resilience, data value creation

1. Introduction

The supply of electronic components was affected by various events in the last few years due to concurring events [1], [2]. These included the rise of blockchain farming, floods, the COVID-19 pandemic which considerably slowed down production, then rising costs due to post-COVID-19 economic start, and the Suez Channel incident. While these turbulences are significant, it is unlikely that they will be followed by a period of stability; instead, continuous perturbations are the norm, which means firms must build their adaptability and flexibility capabilities to be able to survive in a turbulent, continuous change environment [3]. Manufacturing flexibility is influenced by sourcing and delivery flexibility, themselves correlated with a digital transformation strategy and information processing capabilities [4]. Building data capabilities in the context of a digital transformation (DT) should allow companies to adapt their structure, including their technical infrastructure and their processes [3]. Capabilities are the ability to repeatedly use organizational and technological resources in predictable patterns and are associated with value creation [5]. Thus, maintaining their data capabilities during turbulent times could help companies maintain their data value creation

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capacities. While disruptions affect all companies, medium-sized enterprises employing more than 50 but less than 250 persons have more limited resources than multi-national enterprises, which may limit their ability to predict their requirements in inventories or maintain the development of data-driven projects when living through a crisis [6], [7]. Smaller firms also generally have a smaller margin of action when reconfiguring their resources is necessary, which means they often have a lower resilience [8]. There is a distinction between medium-sized and small-sized companies. The larger SMEs in the manufacturing sector are more likely to face uncertainty and turbulence in their environment by turning to information-gathering practices [9]. Medium-sized companies are also more likely than smaller firms to invest in emerging technologies and to consider these investments a priority even in turbulent times [10].

This study aims to shed light on how the conditions specific to medium-sized companies affect their capacity to maintain data value creation throughout instability. We seek to address the following question: *how do organizational learning capabilities influence the evolution of data capabilities and data value creation during disruptions?*

This study would give valuable insights not only into the role of the various capabilities involved and their timing, which could inform decision-makers concerning resource allocation challenges. Practitioners and researchers both benefit from a better understanding of the consequences of such trade-offs, notably on data value creation at both an operational and a strategic level. To maintain comparability, the two companies are in the same industry, operate in the same region, in the same Canadian province, and were of comparable size at the first time point of the study.

In Section 2 we present our conceptual model. Section 3 depicts the case study design. Section 4 puts forward a discussion of the factors influencing data value creation, and finally, Section 5 outlines the implications and conclusion.

2. Data value creation and data capabilities

Commonly applied in information systems to explain performance, the resource-based view assumes firm-specific resources are used in a way that makes them hard for competitors to imitate to drive business performance [11], [12]. Value derived from the use of IT depends on factors such as technological resources, user support, and organizational resources [13]. This view firm holds if the firm is studied within its industry and regional contexts [13], or considering other contingencies, for instance, a firm's resilience [8] or data analysis and organizational learning capabilities [5].

The way to operational and strategic data value creation is conceptualized in this study in three main blocks, as shown in **Figure 2**. The first includes the resources companies must maintain. The second block contains data capabilities. The last block is composed of organizational learning capabilities.

Several types of resources are suggested in the literature on IT value creation. Melville et al. [13] presents the general categories of IT technological resources, IT human resources, and complementary organizational resources. In medium companies, this last category should include the support of senior managers, since their intervention is often more direct in this category of companies [6], [9]. In particular, the alignment of senior managers with the goals of data value generation is of interest [5], [13], [14].

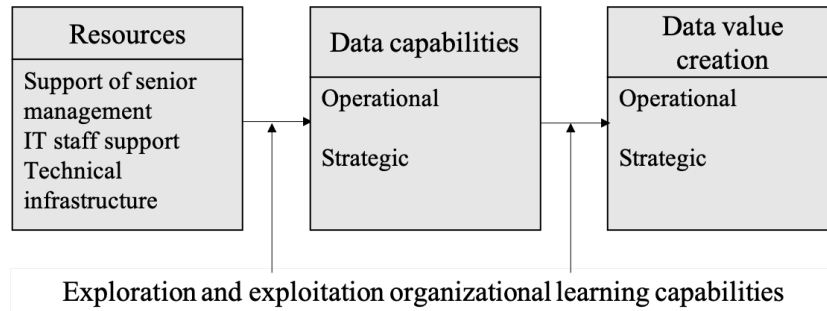


Figure 1: Data value creation and capabilities adapted from [5] and [15]

A further distinction is made between operational and strategic capabilities, defined as how resources are organized and used in a repeatable pattern [12]. Strategic capabilities relate to characteristics of the organization, such as the identification of trends or differentiation. Operational capabilities are more closely linked to process optimization or cost management [5], [8]. Finally, there are capabilities relating to how a firm will evolve and reconfigure its resources and data capabilities, either from exploitation, related to efficiency and developing what is there, exploration, related to innovation, or a combination of the two, in an ambidextrous way [5], [16]. Ambidexterity implies investing simultaneously or in short succession in potentially competing resources in the search for an optimal point [17]. When medium-sized companies must share the same infrastructure, staff and management resources for innovation and efficiency, resource allocation compromises may have to be made [7]. Resources are expected to be positively linked to data value creation, mediated by data capabilities, at least when considering a fixed point in time [5], [15].

The resource allocation challenge in medium enterprises under uncertainty should be further investigated. Managers, notably owner-managers, reorganize their organization based on the turbulence of their environment and the perceived uncertainty [9]. Higher perceived uncertainty is linked to increased information-seeking behavior and innovation orientation, supported by digital technologies. If exploration and exploitation orientation is linked to data-driven transformation in turbulent times, what remains to be demonstrated is how these factors evolve during disruption and how they impact value creation.

3. Case study design

Two Canadian firms in the same industry, manufacturing electronics goods, were heavily affected by the perturbations of the supply chain of electronic components that coincided with the COVID-19 pandemic while they were engaged in a data-driven transformation of their operations. They are currently in the recovery phase. With two measurement points, one before the supply chain perturbances in 2017 and one after, 2023, the approach allows to study of the sequence of effect and contrasts the situation of two firms that had, at the beginning of the study [18]. Comparative designs allow us to understand the differences in two cases despite similarities and draw conclusions on the probable cause of the divergences, which offers a comprehensive perspective based on its context [19].

The first company, M1, has a heavy focus on exploitative learning, especially the improvement of internal efficiency as a value-creation mechanism. The second company, M2,

is a “jack-of-all-trades”, splitting its efforts between exploration and exploitation as value-creation mechanisms. This contrast within the same industry was the main motivation for choosing these two companies. Because the two companies rely on similar electronic components, the perturbations they faced were comparable and allowed to contrast the other factors. The informant of M1 is the administrative vice president, who has been working for years within this company. Amongst other responsibilities, this senior manager supervises the information technology team and champions data valorization initiatives. At M2, a period of instability caused several changes in the management. Whereas in 2017 the interview was realized with the CEO, in 2023 another senior manager was interviewed, namely the director of development and service. This director manages the product development teams, which are in this company the core value-bringer and the center of innovation. The change of interviewee introduces potential limitations in the interpretation of the perception-based questions but reflects the profound changes the company faced in the last years, which must be considered in a study on the impacts of disruption. The definition of the OECD is used for a medium enterprise, employing between 50 and 249 people [20]. Key facts as presented in **Table 1**.

Table 1

Size of enterprises

	M1		M2	
	2017	2023	2017	2023
Employees	Medium (100-149)	Medium (50-99)	Medium (50-99)	Small (>50 emp.)
Turnover	2-19 mio CAD	20-50 mio CAD	2-19 mio CAD	2-19 mio CAD

Both companies lost employees to a mix of layoffs and retirements. M1 saw an increase in its turnover thanks to an increased presence in its sector, while M2 brought back its turnover to the pre-pandemic levels after some rough years. Both firms faced significant price increases for their materials, and thus, the increase in turnover of M1 does not translate to higher profits. Instead, both companies saw a diminution in their profits over the turbulent period. The interview guide started with open-ended questions to get a better understanding of the context surrounding the data-driven transformation in the company and the consequences of the supply chain perturbations on their activities. Then came a series of questions concerning the factors in the conceptual model [5].

4. Results

M1 and M2 operate in the same Canadian province but have customers worldwide. Both are developing turnkey solutions in addition to offering a catalog of base products with personalization options. They have large design and engineering departments. They have internal information technology teams and do not rely on outsourcing to fill their IT support or development needs. At the first time point, in 2017, they had similar turnover and number of employees, although M2 in 2023 now fits in the small enterprise category.

4.1. M1: strong data management and operational focus

As shown in **Table 2**, M1 initially showed high levels of the three types of resources: their senior management was closely involved in the development of data-driven changes and had a culture of making decisions based on data. Their data infrastructure was centralized and their

IT staff supported the users while letting the different work teams take the lead of the projects. Their data capabilities, both operational and strategic, were also high thanks to a culture of data-driven decision, real-time data analysis, and business orientations based on market and customer data. Their operational and strategic value creation was only moderate, based on the perception of the interviewee compared to the competition.

Table 2
Case summary of M1

Factor	Explanation
Senior management.	Data valorization is a recurring theme in board meetings. The board has a data-supported decision habit. Increase: data governance and guidelines were reinforced to prepare for more real-time analytics.
IT staff support	Small IT team with a business support focus. Similar: minor changes.
Infrastructure	Basic systems (ERP, CRM, reporting system) are available, and manual data copy is limited. Similar: the infrastructure is equivalent, but the change of ERP caused perturbations.
Operational data capabilities	Culture of basing day-to-day decisions on data and KPIs long established, data is available without major manipulations and used. Increase: Incremental improvements in several aspects, real-time analysis, a broad range of data available, increase of use by operational workers.
Strategic data capabilities	Varied KPIs available and used, computed without human intervention, giving a complete view. Market intelligence available. Increase: refined market and competition analytics capabilities, i.e. to detect supply chain disruptions.
Exploitative organizational learning	Focus on operational efficiency and performance in existing markets. Product improvements aim to perform better in existing niches. Similar: slight increase due to renewed efforts to improve existing processes with new systems
Explorative organizational learning	Diversifying and innovation outside of niche are not priorities. Similar: slight increase due to the search for new markets.
Operational data value creation	Initial: well positioned compared to competitors, but not top of the lot. Similar: operational performance was maintained through disruption.
Strategic data value creation	Initial: well positioned compared to competitors, but not top of the lot. Similar: slight decrease of margins and achievement of business goals, slight increase in market understanding.

There are competing explanations. M1 in 2017 had a focus on exploitation activities. Organizational learning ambidexterity is thought to be a moderator of value creation, thus a firm with a low ambidexterity would have lower benefits from its data capabilities [5]. Another explanation is the competitive environment, so fierce that it is necessary to invest a lot of resources simply to maintain its position. For medium-sized enterprises, there are fewer resources dedicated to the development of data-driven changes when these changes are not part of the core business [7]. The managers responsible for data-driven changes split their time and efforts between operations and the search for innovative solutions, which leads to fewer opportunities being captured.

In 2023 M1 maintained its position regarding operational and strategic value creation. On the one hand, it could be expected that with higher operational and strategic data capabilities, value creation would have increased [5]. On the other end, M1 faced major challenges in terms of inventory supply, delivery time, and production costs. In terms of anticipation of the

disruption, M1 could count on predictive sales models that reacted as soon as orders started to drop. Their production and inventory management indicators also allowed them to react and increase the inventories to get a larger buffer. During the disruption, information visibility was made more difficult by the transition of the ERP. The operational efficiency at M1 allowed them to adapt and stay afloat, although with higher lead times and lower margins of profits. These elements are known to contribute to the resilience of a firm to supply chain disruptions [21]. The challenges at M1 appear mainly in the recovery phase. The firm has the competencies and the information-sharing practices in place to help recover from the disruption, but the challenges considering the visibility of data spread across different systems and velocity of the systems (challenges in displaying real-time data, the MES implementation project being late) are key links that are missing for a prompt recovery [22]. In other words, the comparatively lower emphasis on explorative activities meant the data capabilities were developed with a more operational focus in mind, which impacted the development of more advanced analytics applications. These advanced analytics could have a moderating effect on the link between data-driven transformation and resilience capabilities [23]. M1 limited their potential value creation out of their data capabilities with a lower focus on exploration, but their exploitation level was enough to maintain their data value creation levels through the disruption.

4.2. M2: balancing efficiency and innovation while building for growth

The case of M2 is summarized in **Table 3**. They had in 2017 a low level of IT support, focusing mainly on maintaining the operational systems instead of supporting data-driven applications. This translated into lower operational data capabilities, as expected from the literature [5] since the employees of the various work teams had to develop their applications, which were then not integrated. Their operational value creation was moderate compared to the competition, based on the interviewee. This could be explained by the ambidexterity of their development team, including their quality control team, since ambidexterity is known to be linked to several types of performance [17]. The development, based on short agile cycles, allows M2 to be flexible and adaptable in the development and delivery of products, which is linked to more value derived from data-driven activities [24]. An inverse phenomenon may be observed on the strategic side. Despite a data-driven culture, central systems such as an ERP and a CRM being available and managers making the effort to use them, strategic value creation is low. The interviewee insisted at several points during the interview that data on the competition and the state of the market in general is hard to use, either because it is not integrated with the CRM, or because it is mainly a perception of the different vendors. Thus, despite good skills at using what they have, what they have does not appear to be sufficient to be able to anticipate market trends, and opportunities of new features or products or gain market shares.

Table 3
Case summary of M2

Factor	Explanation
Senior management.	Management tries to implement data governance and promote the use of data, but lots of manipulations are necessary. Decrease: major changes in upper management and weaker data-based decision culture.
IT staff support	IT staff mainly supports critical operation systems. Increase: formalization of IT structure and processes to diminish impacts of personnel turnover.

Infrastructure	Basic systems are available but missing reporting functions and not all functionalities are used. Low level of integration between systems. Similar: no major changes, challenges are the same.
Operational data capabilities	Data is mostly available in operations but difficult to get and requires manipulation. Increase: incremental increase in all aspects.
Strategic data capabilities	Main weaknesses: the lack of market data and the need to manipulate data before use. Similar: incremental increase in the availability of data, but manipulation is still necessary.
Exploitative organizational learning	Cost control and delivery times are central in product development. Similar: processes and existing products were streamlined, but without a change of strategic focus.
Explorative organizational learning	Survival of the company was always linked to innovation capacity. Increase: new product lines open new markets and are based on disruptive innovations.
Operational data value creation	Internal control a strength, but performance compared to competition could be improved. Decrease: mainly due to higher development times, loss in production efficiency, and quality control issues.
Strategic data value creation	Company struggled with market shares and answer to competition. Increase: mainly due to new innovative product, market position is better.

In 2023, M2 derived less operational value from its data, a phenomenon that seems to be linked with the perturbations in the upper management that caused slowed or stopped operational data-driven transformation projects, combined with a low starting level of operational data capabilities. Operational data capabilities are directly linked to operational value creation [5]. In the pre-disruption phase, operational skills such as inventory management, as well as information sharing and visibility impact the firm's ability to overcome a supply chain disruption [21]. At M2 some data concerning inventory levels related to expected production is available, but the visibility is low due to the systems not being convenient combined with a low level of integration, which means to get access to the indicators, data manipulation has to be done. Even if operational managers wish to be transparent and share information, in situations of emergencies the additional effort to compute the data and present it in a form useful for upper management is unlikely to be done. Strategic value creation has taken the opposite path at M2, despite operational problems caused by the supply chain disruptions. This is partly due to their new, innovative product family being less dependent on electronic components, and thus, the disruptions have a lesser impact on the development and production process. A similar phenomenon is observed in companies using additive manufacturing to gain flexibility and improve the ability to quickly reconfigure the production [25]. In both cases, there is a reduction of the dependence on classical manufacturing and supply, based on innovative technologies. Still, the development of this product at this point was not a pure coincidence. For years the management at M2 has known this avenue represented a market development opportunity and has prepared its introduction. Innovation performance is influenced by explorative learning capabilities in addition to data capabilities [26]. The increase in strategic data value creation is the direct result of a focus on exploration capabilities.

5. Implications and conclusion

Both firms increased their data capabilities over time, regardless of changes in the availability of resources. Organizational learning capabilities tended to stay stable, confirming previous

findings that found companies locked their organizational learning preferred style [27]. The evolution of factors is shown in **Figure 2**.

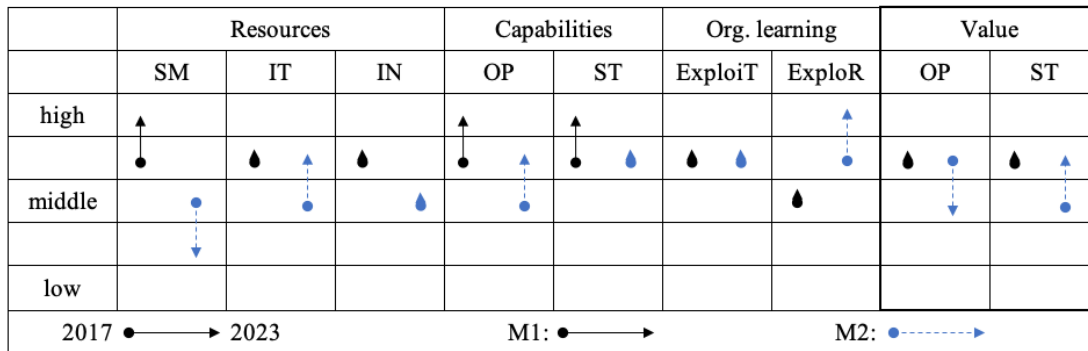


Figure 2: Effect over time on data value creation under disruption

Previous studies state higher senior management resources and strategic data capabilities should correlate with higher strategic value, and higher IT, infrastructure, and operational data capabilities should correlate with higher operational value [5], [15]. We hypothesize that differences are explained by the impact of the organizational learning style under disruption. In this case, (1) For M1, higher senior management resources and strategic capabilities are not correlated with higher strategic value. (2) For M1, higher operational data capabilities are not correlated with higher operational value. (3) For M2, despite lower senior management resources, strategic value is higher. (4) For M2, despite higher IT and operational data capabilities, operational value is lower.

In M1, the focus on exploitation leads to constant data value creation during the disruption, despite high material costs and fierce competition. Relying on exploitation during uncertain periods has been observed in previous studies [28]. High exploitation capabilities before and during the disruption seem to have a protective effect on firms' value creation out of data capabilities. Specifically, it seems to help shield the firm from the adverse effects of the disruption and help the firm maintain equal levels of value creation. While M1 benefited from this effect, at M2 compromises had to be made because of limited resources and a strategic choice to further favor explorative learning. Furthermore, entrepreneurial orientation significantly impacts a firm's capacity to reconfigure its resources [29], which may explain why M2 doesn't benefit from their exploitation as much as M1. The protective effect of high exploitation could be due to anticipation and early detection of the impact of the disruption on the manufacturing and delivery process, data visibility, transparency, and information sharing [22], [23], but only when combined with high senior management implication. When the operational processes are more efficient, costs and processes are optimized and the firm is used to implementing gradual improvements, reconfiguration to adapt to the disrupted situation is easier. Still, a firm that focuses on neglects exploration risks becoming obsolete [17]. The management team at M1 is well aware of this, which is why efforts have been dedicated to augment explorative capabilities in the last few years. This phenomenon leads to the formulation of a research proposition **P1** Exploitative organizational learning combined with

higher involvement of senior management prevents operational and strategic value from disruptive events.

In M2, ambidexterity leads to a trade-off of diminished operational data value creation during the disruption in favor of an augmentation of strategic data value creation in the recovery phase. Exploration capabilities combined with exploitation seem to have a ramp effect in the recovery phase for strategic value creation, which correlates with previous studies linking ambidexterity, and high exploration, to performance [17], [26]. From an operations perspective, M2 in 2023 is still in a recovery phase, with a production backlog of several months. However, the focus of the firm on innovative new products and developing new market segments has allowed them to continue to develop their brand. The satisfaction of their customers is rising and the firm has improved its market position both in terms of market share and in reputation in its industry. How this position would evolve remains to be seen, since long-term survival does require operational value creation, notably financial. A firm that has a high exploration level but comparatively low exploitation would be unlikely to be able to continuously capture the value of its innovations [17]. They could even see their performance impaired by this imbalance [16]. This leads to **P2** High exploration when combined with exploitation capabilities helps firms recover strategic value after disruptive events.

If a cross-sectional survey shows a direct link between data capabilities and value creation [5], [24], this study shows that more complex effects are involved when the evolution of data value creation is observed over time. This study also suggests considering the impact of exploitation and exploration at different phases of a disruption. When a firm is going through a disruptive event, particularly a medium-sized enterprise where those in charge of the data-driven transformation also have operational responsibilities, fewer resources may be dedicated to innovation and the focus will turn to operational efficiency. Having a higher level of exploitation capabilities before the disruption may help limit the value creation loss. The impact of exploration appears to be felt later when resources can once again be dedicated to innovation.

The study is limited by the inclusion of only two companies of the same size, in the same industry. These similarities allow us to compare their differences concerning organizational learning capabilities, but generalization is not possible. In the same vein, the study included a company with a high level of exploitation and a low level of exploration and a company with a moderate level of both. It would be interesting to include a company with a low level of exploitation and a high level of exploration, for instance, a young company with a heavy innovative focus, to see if the observed impact of organizational learning capabilities on data value creation is also valid for these types of company. Only one informant per company per time point was used, which potentially introduces personal bias, which is why care for taken to select informants most likely to provide insights on data value creation and digital transformation initiatives in their respective companies. Finally, although a detailed interview guide was used to ensure a sufficient variety of themes was covered, the study has the same limitation as other interview-based studies: there is a potential bias introduced by the interviewee or interviewer.

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