

Four Steps to Realizing Business Value from Digital Data Streams

Based on four case studies and a follow-up survey, we have identified the key success factors for realizing value from DDS (digital data stream) investments. But managers need to pay attention to the combinations of success factors. A key finding is that value realization is improved when the agility of the resource allocation process is appropriate for the levels both of DDS platform maturity and of commitment from data-driven top management. We present a four-step sequence and a decision framework for putting the optimum combination of success factors in place.^{1,2,3}

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Digital Data Streams and Business Value

Firms are increasingly using real-time digital data streams (DDSs) to create business value.⁴ A common feature of DDS-based applications is that they integrate real-time data from multiple sources to create valuable new products and services. These applications typically employ advanced techniques, such as sophisticated algorithms, artificial intelligence and machine learning to splice, integrate and analyze real-time data, and to take decisions in real time in ways that can have a profound impact on creating business value.⁵



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4 See Piccoli, G. and Pigni, F. "Harvesting External Data: The Potential of Digital Data Streams," *MIS Quarterly Executive* (12:1), 2013, pp.53-64; Piccoli, G. and Watson, R. T. "Profit from Customer Data by Identifying Strategic Opportunities and Adopting the "Born Digital" Approach," *MIS Quarterly Executive* (7:3), 2008, pp. 113-122.

5 Pigni, F., Piccoli, G. and Watson, R. T. "Digital Data Streams: Creating Value from Real-Time Flow of Big Data," *California Management Review* (58:3), 2016, pp. 5-25.

For instance, General Electric's (GE) Aviation Digital Solutions employs DDSs to improve the performance of its airline customers.⁶ One of GE's DDS-based products integrates real-time data on wind speeds, ambient temperatures, engine thrust and other parameters and provides the integrated data to its customers, such as Southwest and Qantas. Airlines use this data to optimize the cost drivers on each phase of a flight—taxiing to the runway, taking off, climbing, cruising, descending, approaching, landing and taxiing back to the gate. Another GE DDS-based product integrates real-time data captured by GE turbines in aircraft flying from one point to another (say London to New York) and aggregates it into a DDS feed to inform aircraft that are following on a similar flight path, helping them to improve fuel efficiency. Organizations such as GE and many others are increasingly investing in DDS-based innovations to underpin the next wave of products and services.

An important issue for organizations is what they should do to capture business value from emerging technologies. Although prior literature has focused extensively on identifying success factors, recent management literature has begun to stress the role of managers and organizational processes in creating value from new technologies.⁷ Accordingly, this article examines the roles of managers and organizational processes in creating value from DDS investments.

Managers play two critical roles in realizing the value-creation potential of DDS-based innovations⁸, even though they do not play any direct role in processing the real-time data:

1. They generate ideas for DDS-based innovations that potentially create value for organizations. This is a critical role that managers play as entrepreneurs.

2. They play a vital role in conceptualizing, designing, developing and continually refining the infrastructure for integrating multiple DDSs, analyzing the data and developing and deploying the automated algorithms for prediction and data-driven decision making.

However, the role of managers in realizing business value from organizational investments in DDS has often been obscured by the automated generation of DDSs and the real-time algorithm-driven analysis of the data.

The automated nature of DDSs has also tended to obscure the role that organizational processes play in realizing value from DDS innovations. Investment in a DDS infrastructure is akin to an options generator.⁹ Like other investments in IT infrastructure, DDS investments create value from the applications that sit on top of the infrastructure. As an analogy, consider the successful investments in data warehouses described by Kohli (2007) and Anderson-Lehman et al. (2004).¹⁰ Both articles describe multiple applications developed by managers over a period of time that created value from an initial investment in the IT infrastructure. However, we do not yet have a clear picture of the role that organizational processes play in influencing managers to undertake DDS-based innovations. That is, we lack an answer to an important question: *What should firms do to realize business value from their investments in DDS innovations?*

While the technical aspects of DDS innovations have received considerable attention in the literature, less consideration has been given to the organizational interventions needed to realize value from such innovations. To understand the drivers of business value realization from DDSs, we carried out a multi-method research investigation. First, we conducted a series of case studies and interviews in four organizations to obtain preliminary insights into the phenomena. We followed this up with a survey to validate

6 Egan, M. *How Big Data and the Industrial Internet Can Help Southwest Save \$100 Million on Fuel*, GE Reports, 2015, available at <http://www.gereports.com/big-data-industrial-internet-can-help-southwest-save-100-million-fuel/>.

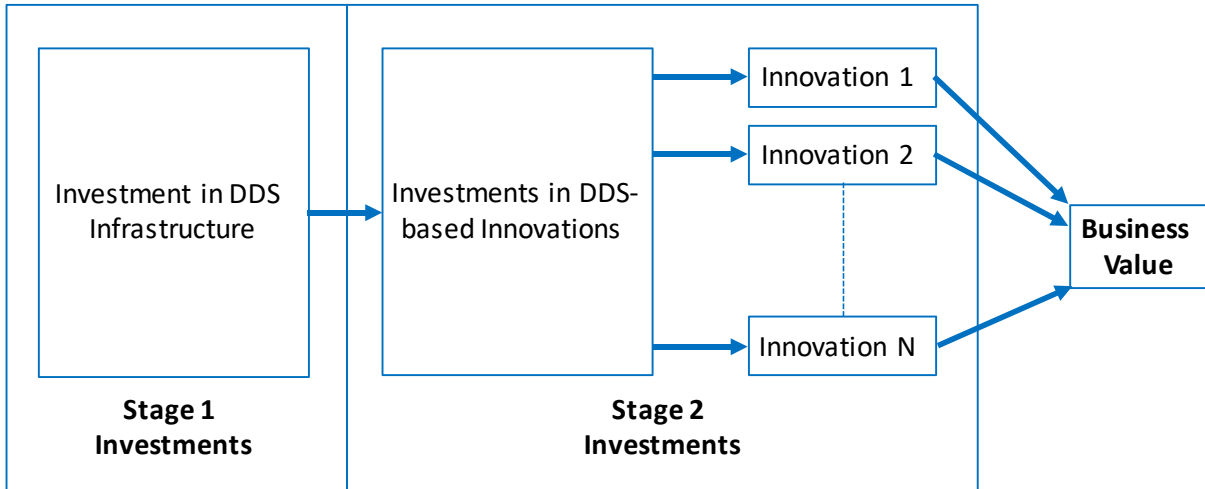
7 See Sharma, R., Mithas, S. and Kankanhalli, A. "Transforming Decision-Making Processes: A Research Agenda for Understanding the Impact of Business Analytics on Organizations," *EJIS Editorial: Special Issue on Transforming Decision-Making Processes* (23:4), 2014, pp. 433-441; Watson, H. J. "Tutorial: Big Data Analytics: Concepts, Technologies, and Applications," *Communications of the Association for Information Systems*, (34:1), 2014, p. 65.

8 DDS innovation and DDS based innovation are used interchangeably in this paper.

9 Sambamurthy, V., Bharadwaj, A. and Grover, V. "Shaping Agility through Digital Options: Reconceptualizing the Role of Information Technology in Contemporary Firms," *MIS Quarterly* (27:2), 2003, pp. 237-263.

10 Kohli, R. "Innovating to Create IT-based New Business Opportunities at United Parcel Service," *MIS Quarterly Executive* (6:4), 2007, pp. 199-210; Anderson-Lehman, R., Watson, H. J., Wixom, B. H. and Hoffer, J. A. "Continental Airlines Flies High with Real-Time Business Intelligence," *MIS Quarterly Executive* (3:4), 2004, pp. 163-176.

Figure 1: Two-stage Investment Process for Realizing Value from DDSs



and extend the insights obtained during the case studies phase of the research.

Our analysis of interviews with senior managers in the case organizations suggests that not paying attention to the roles of managers and organizational processes can limit an enterprise’s ability to realize business value from its DDS-based investments. Specifically, our interviews reveal that creating value from DDS investments involves a two-stage investment process (see Figure 1).

Stage 1 involves a large investment in DDS infrastructure, while Stage 2 involves a continuing stream of small to medium-sized investments in DDS-based innovations that create value from the initial investment in the DDS infrastructure. Although the non-availability of Stage 2 innovation capital can undermine an organization’s ability to capture business value from DDSs, its availability does not guarantee either innovation or the creation of business value—realizing benefits depends on several success factors being in place and the operation of managerial and organizational processes during Stage 2. The critical role of Stage 2 innovation capital does, however, highlight the need to understand the key role of organizational resource allocation processes in realizing business value from organizational investments in DDSs.

We first describe the case study-based research and the key insights from the cases for DDS-based value creation. We then describe the follow-up survey research and present the key findings that emerged from our survey analysis. Based on those insights and findings, we present a four-step sequence for developing an appropriate set of conditions required for creating value from investments in DDSs. We also describe a decision tree to aid managers in deciding the appropriate sequence of steps for realizing value from DDSs.

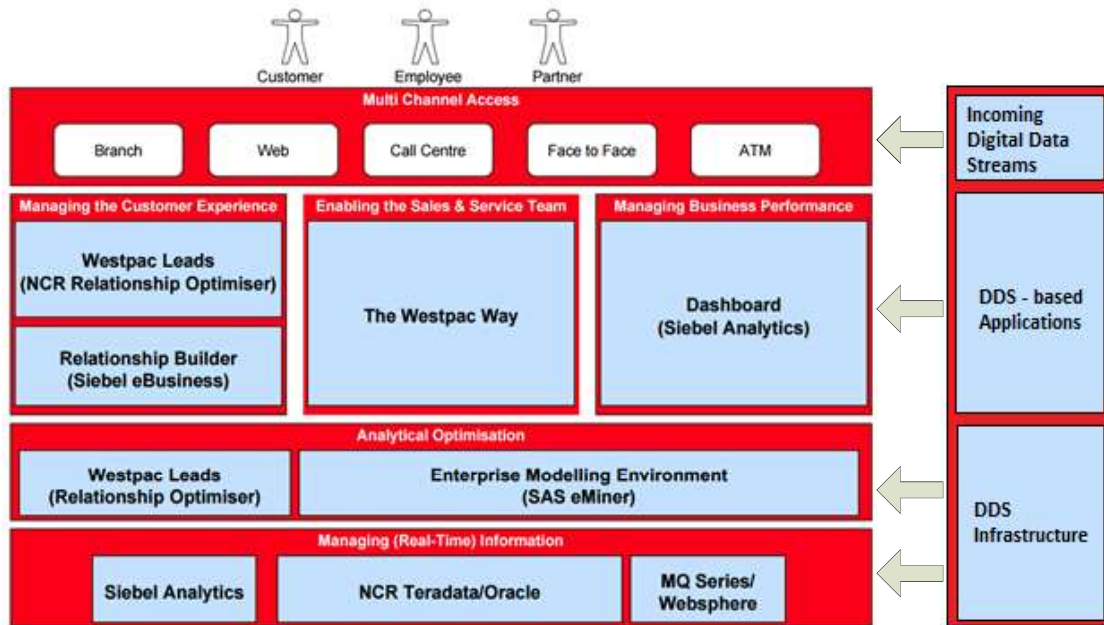
Four Case Studies of DDS-based Applications

The organizations in the case study phase of our research are Westpac (a full-service bank), the Australian Taxation Office (a government organization), Western Union (a U.S.-based financial services firm with international operations) and DHL (a global logistics services firm). In addition to conducting interviews with senior executives, we also reviewed publicly available archived information, including white papers, campaign reports and articles, and governance and annual reports.

Westpac

Westpac is one of the biggest financial and banking services providers in Australia. It is using

Figure 2: Schematic of Westpac’s IT Architecture for Leveraging DDSs¹⁰



multiple real-time DDSs (see Figure 2) generated from multiple sources (customers, employees and partners) interacting with the bank through various channels (e.g., branch, Internet, call center, face-to-face, ATM) to underpin multiple value-adding DDS-based applications. These applications support Westpac’s operations in diverse areas (e.g., managing the customer experience, enabling the sales and service team, and managing business performance). For instance, the bank uses a product promotion application (NCR Relationship Optimiser) that is triggered when a client swipes a card at an ATM or at a teller’s terminal. That real-time data triggers the application, which pulls up the customer’s profile and recent transaction history. This data is fed into models that take into account a host of customer-related factors, such as stage of life and current and projected financial demands, to identify the bank’s products that would be most attractive to the client. This information is then fed in real time to the ATM

terminal or the teller’s screen and to a centralized call center for follow up.

Australian Taxation Office

The Australian Taxation Office (ATO) is the government agency responsible for administering the federal taxation system. The ATO is leveraging its DDS feeds of individual and corporate tax returns in several applications, with the aim of improving the efficiency of its processes, improving customer service and ensuring greater compliance and fraud detection. One of the applications is a data-pattern matching system to detect inconsistencies, errors and potential fraud in the incoming DDS of tax returns. This application automatically processes incoming data streams of tax returns and integrates it with warehoused data from multiple DDSs coming from banking transactions, credit card transactions, airport departure data and an expanding stream of other relevant digital data sources. It then makes near real-time decisions on the follow up actions to be performed for each tax return—for instance accepting the return, rejecting it and identifying the errors to be corrected, or referring it for fraud or compliance investigation.

11 Reproduced with permission from Westpac, Australia. For more information, see Pratt, M. *Turning conversation into sales – CRM at Westpac*, Westpac, 2015, available at https://www.westpac.com.au/docs/pdf/aw/ic/050330_MTP_APacKL.pdf.

Western Union

Western Union is a major global provider of foreign exchange services. Its operations generate a range of DDSs as customers across the world use its digital services to transfer money, pay bills and buy or reload prepaid debit cards. The company also accesses other DDSs, such as exchange rates and the credit profiles of individual customers. One DDS-based application Western Union has developed is to optimize pricing at an individual and transactional level to achieve greater efficiency from its DDS-based pricing platforms. This application employs a variety of advanced technologies to splice and analyze multiple DDSs, such as real-time foreign exchange transactions, clickstream data and logs of customer usage patterns. The processed data is fed into a centralized optimal pricing system that generates quotes for customers in near real time.

DHL

DHL is the world's premier logistics and express courier service provider. It makes extensive use of real-time data streams to support the delivery of its parcel and express shipments to international destinations in more than 250 countries. Data about every shipment is continuously collected using radio frequency identification and scanning technologies at every checkpoint in the global network, creating a DDS that is transmitted to the centralized Quality Shipment Monitoring System. One way in which this DDS is used is to integrate it with other real-time data streams such as weather conditions, operational activities and other data that impacts shipping schedules. The centralized application integrates these multiple data streams in real time and, among other actions, informs customers of any implications for their shipments. Investments in DDS infrastructure and DDS-based innovations have enabled DHL to evolve its business model. It no longer offers just basic features, such as greater choice of air or ground services, reliability of overnight or second-day delivery and door-to-door pickup and delivery, but has evolved to become a premium service provider that proactively meets growing customer expectations.

The four case organizations illustrate the diverse ways in which DDSs have been deployed to create business value across different

industries. However, it would be naïve to assume that DDS investments will automatically lead to organizations realizing greater strategic and operational value. The path to value realization is far more complex, and we still lack answers to important questions regarding the combinations of success factors that are necessary to fully exploit the value-creating potential of DDSs. Below, we describe the important success factors that influenced how the case organizations realized value from their DDS investments.

Insights from the Case Studies on Realizing Value from DDSs

One insight that emerges from our analysis of the case organizations is the role of managerial entrepreneurship in creating DDS-based innovations at Stage 2 of the investment process (see Figure 1). The business value that a DDS application can potentially create is not obvious. A variety of skills are necessary in Stage 2 to convert investments in DDS infrastructure into innovations that create organizational value from digital data. Managerial skills are needed to identify potentially valuable applications, analytical skills are needed to infer meaningful patterns in data and entrepreneurial skills are needed to pull together the required resources.¹² Moreover, although DDS-based innovations may be leveraging DDSs for real-time algorithm-based decision making, the applications and algorithms underpinning them would have been initiated and developed by managers.

In other words, an evaluation of the potential value of a DDS most likely proceeds in an offline mode where managers check out some hunches for creating business value via an innovative DDS application. They then evaluate the value-creation potential of those hunches and make considered decisions on whether to invest in developing a DDS application that exploits those hunches. An investment decision is then followed by resourcing, developing and testing the DDS application before it is employed in production for real-time decision-making.¹³

12 See Coltman, T., Devinney, T. M. and Midgley, D. F. "Customer Relationship Management and Firm Performance," *Journal of Information Technology* (25:3), 2011, pp. 205-219; Pigni, F., Piccoli, G. and Watson, R. T., op. cit., 2016; Sharma, R., Mithas, S. and Kankanhalli, A., op. cit., 2014.

13 Piccoli, G. and Pigni, F., op. cit., 2013.

A significant amount of managerial decision making and judgment is involved in identifying promising DDS applications and in deciding which applications to resource, when to resource them and how much to resource them. Thus, it is critical to understand what organizations need to do to accelerate DDS-based innovations and capture business value from investments in the DDS infrastructure. Our analysis of the four case organizations revealed three critical success factors for realizing value from DDS investments—agility of the resource allocation process, commitment from data-driven top management and the maturity of the DDS platform.

1. Role of the Resource Allocation Process in Building DDS-based Innovations

A key insight is that, although the case organizations had made investments in DDS infrastructure, they had not paid sufficient attention to the processes of allocating resources for DDS-based innovations. In particular, managers complained about the difficulty of obtaining resources for developing DDS applications:

"We've got the money to build the model but not to be able to find a way of actually getting it into production ... You can't always go and look for money because that takes time and effort." Head of Data and Systems Management

Although organizations typically had processes to provide Stage 2 innovation capital (See Figure 1), these processes were often considered very cumbersome and bureaucratic:

"If you have an idea, and it's going to cost less than \$100,000, you can put it onto the website, and then a committee goes through it." Head of Data and Systems Management

To circumvent bureaucratic resource-allocation processes, managers often relied on other informal and more agile resourcing options to expedite innovations, such as exploiting their

relationships with colleagues to extract spare budget or tapping their own slush funds:

"Sometimes you need to go and find someone who has money ... We also tend to have our own slush funds." Head of Data and Systems Management

Another important insight on resource allocation is that line managers have available to them a variety of structural arrangements for obtaining resources to pursue DDS-based innovations. These arrangements have varying levels of agility and bureaucracy. For instance, line managers may have their own budgets and slush funds that can be utilized to support DDS-based innovations at their own discretion, which means the allocation process is highly agile. At the other extreme are low-agility, formal and bureaucratic processes for obtaining centralized funds through formal proposals and reviews by top management. Rigid bureaucratic resource allocation processes inhibit the ability to create value from DDSs:

"You wouldn't be able to get very much done if it takes you a month or two months or six months to get money." Head of Data and Systems Management

The findings from the case studies highlight the important role of resource allocation processes in creating DDS-based innovations and realizing business value.

2. Commitment from Data-driven Top Management

In the case organizations, senior managers who understood the value of data played a key role in generating the cultural and behavioral changes that were necessary to drive investment in DDS-based innovations:

"... certain key executives have come into the organization ... that's made a lot of difference to us ... The evolution really has been, I think, more cultural or behavioral than it is technological." General Manager, Performance and Analytics

These managers had a vision of the future for digital business strategies and articulated the strategic case for investing in digital infrastructure that inspired an ambitious pursuit of innovations to realize business value. The Head of Metrics and Reporting in one case organization said: *“We poured 70 to 80 million into digital infrastructure over a four-year period.”* This investment underpinned DDS-based and other applications. In the words of the General Manager, Performance and Analytics, the initial investment was followed up by *“a lot of investment on top of that ... in risk ... marketing ... customer profitability [applications].”*

Data-driven top managers not only ensured the development of technical capabilities. They also fostered the development of human capital and the introduction of structural arrangements that enabled technical and business functions to be integrated, an essential prerequisite for creating successful DDS-based applications:

“... one of the things where we’ve had success is migrating people out of the analytics team into the business functions ... So the way that I organized the team was ... if you go down one level again ... we are organized by the business areas ... product ... marketing ... risk, and each of those people is sitting on the management teams of those business units.” Head of Analytics Transformation

High levels of commitment, personal involvement and support by top management for DDS-based innovations gave clear signals to line managers that DDSs are important and valued in the organization, motivating line managers to spend effort in exploring and evaluating DDS applications.

3. Maturity of the DDS Platform

The managers we interviewed were actively building more mature platforms to enhance the speed at which new DDS-based innovations could be developed. Managers leveraged the infrastructure to “slice and dice” real-time and static data, to splice and integrate the data, and to examine potential value-creating DDS innovations (see Figure 2 as an example from one of our case studies). More mature DDS platforms enabled

the specialist digital data support teams and line managers to develop a deeper understanding of the data and its value-creating potential, and to accelerate the exploration and evaluation of DDS innovations.

“The enterprise data warehouse does traditional stuff like extract, transform, load from transaction systems ... The data hub [more mature platform] is closer to real time, so the data is available from transaction systems but also from online systems and from other things, and then its available for use ... in near real time.”
Senior Director, Corporate Analytics

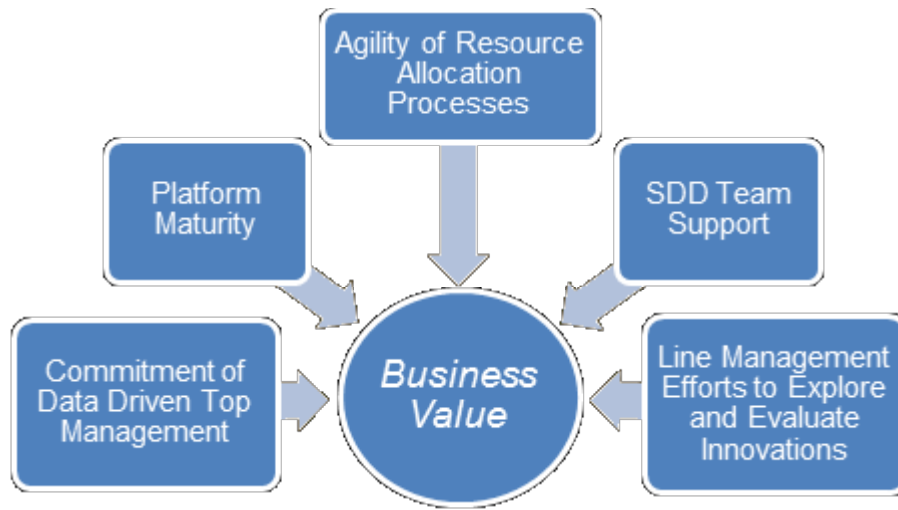
The more mature an organization’s data infrastructure platform is, the easier it is for managers to integrate multiple static and real-time data sources into new value-creating DDS applications. A mature platform also enables greater re-use of data, allowing data to be combined and recombined in real time to underpin new products and services. For instance, our case study research found that managers in organizations with more mature platforms were leveraging the predictive and prescriptive capabilities of these platforms to discover actionable insights that could be automated and deployed as DDS-based products or services.

Research Survey and Design

The case studies identified three key success factors for realizing business value from DDSs—the agility of the resource allocation process, commitment from data-driven management and the maturity of the DDS platform. Management commitment and platform maturity have been identified as generic success factors in the context of many technologies, including business analytics and DDSs. However, agility of the resource allocation process is specific to the success of the DDS and other digital data infrastructures, such as business analytics applications, because of the two-stage nature of the investment process for realizing value from DDS investments (see Figure 1).

Much has been written about the role of critical success factors in the success of various technologies. Success factors, however, operate

Figure 3: Success Factors for Realizing Business Value from DDS-based Investments



in conjunction, rather than independently. To obtain deeper and more general insights into the realization of business value from DDSs, we carried out a follow-up survey to investigate the joint effects of the agility of the resource allocation process, extent of commitment from data-driven top management and platform maturity.

We surveyed line managers from medium-to-large organizations in Australia and New Zealand. The survey instrument included items to measure the effects of two additional success factors that other researchers have identified as influencing the realization of business value—the extent of support offered by the specialist digital data (SDD) support teams to line managers and effort spent by line managers on exploring and evaluating innovations (see Figure 3). We provide below brief descriptions of how the survey measured business value and the key success factors. (Details of the survey, including descriptions of the survey constructs,¹⁴ survey instrument validation, survey items and respondents’ demographics, are provided in Appendices 1, 2, 3 and 4, respectively).

Business value was measured by asking respondents to answer questions about the innovations in products, services and customer

segments introduced in their unit, as well as the performance gains their unit had realized from those innovations. To validate the respondents’ assessments of business value, we correlated them with objective financial data obtained from publicly available financial statements.¹⁵ This comparison provided strong confidence in the validity of the respondents’ measures of business value.

Agility of the resource allocation processes, which determines the ease with which managers can obtain Stage 2 innovation capital to resource DDS innovations, was measured by asking questions about two key aspects of organizational control on innovation capital: centralization and formalization. The level of centralization was measured by asking about the extent to which decisions for sanctioning organizational resources for DDS innovations are concentrated with senior managers. The level of formalization was measured by asking about the extent to which managers need to request resources for DDS innovations through formal channels and follow formal processes. Both aspects reflect how easily line managers can obtain resources to convert insights into innovations.

¹⁴ In this context of a survey, a “construct” is the characteristic to be measured.

¹⁵ A strong correlation was found between the respondents’ measures of business value and average profit margin over the five-year period 2010-2014 and average return on assets over the same five-year period.

Platform maturity was measured using an existing scale for maturity across four key capabilities: data management capability, system integration capability, reporting and visualization capability, and predictive discovery capability. This scale draws on and integrates measures of platform maturity described in the practitioner literature.

Commitment of data-driven top management was measured by asking about the actions undertaken by the respondents' managers to support DDS innovations—for instance, approving projects, committing resources to projects and involving themselves personally in ongoing projects.

The extent of support from the *SDD support team* was measured by asking questions about the time spent by the SDD team with line managers and their teams, the training delivered by the SDD team to line managers and their teams, and the extent to which the SDD team was able to demonstrate to line managers the business value that they could deliver.

Effort spent by line managers on exploring and evaluating DDS innovations was measured by asking line managers about their actual efforts—e.g., the amount of time spent on data-driven innovations, the number of projects initiated and the number of meetings they took part in to discuss data-driven innovations.

Survey Findings on How Agility of Resource Allocation Process Affects Business Value

Our analysis of the survey data¹⁶ focused on identifying the effects of combinations of key success factors on realizing value from DDS investments. Specifically, we examined the joint effects of (1) the agility of the resource allocation process with platform maturity and (2) the agility of the resource allocation process with commitment of data-driven top management. We chose this approach because, as mentioned above, success factors operate in conjunction rather than independently. For example, the extent to which DDS-based innovations can create value could be determined by platform maturity (a more mature platform enables more valuable DDS innovations

to be discovered) *and* the ease with which organizational resources can be made available to develop the innovations. The key findings from our analysis of the survey data are presented below.

1. Joint Effects of Agility of Resource Allocation Process and Platform Maturity

The survey findings show that the agility of the resource allocation process in combination with platform maturity exerts a strong influence on business value (see Figure 4a).¹⁷ When the agility of the process is low, increasing investment to create a more mature platform results in only a small increase in business value (shown by the dotted line in Figure 4a). However, when the agility of the process is high, investing in the platform results in a much larger increase in business value (shown by the solid line in Figure 4a).

The survey findings represented in Figure 4a suggest that the ideal condition for realizing business value when platform maturity is low is to have a low-agility resource allocation process. However, increasing business value when platform maturity is high is obtained only when the agility of the resource allocation process is also high.

2. Joint Effects of Agility of Resource Allocation Process and Extent of Data-driven Top Management Support

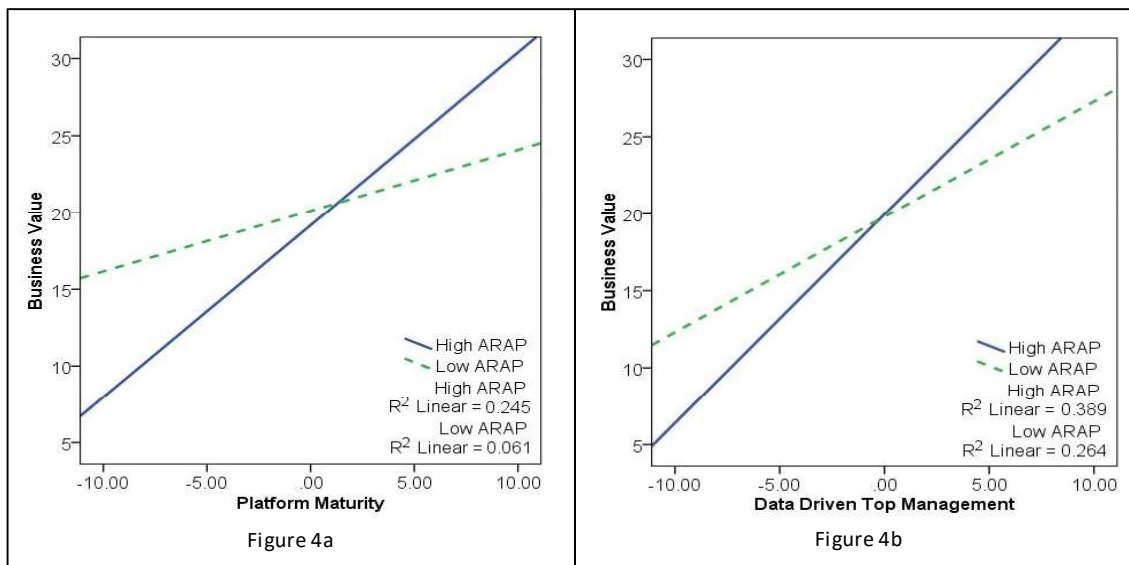
The agility of the resource allocation process in combination with the extent of data-driven top management support also exerts a strong influence on business value (see Figure 4b). Increasing commitment from data-driven top management results in a much higher increase in business value when the agility of the resource allocation process is high (shown by the solid line in Figure 4b) than when the agility of the resource allocation process is low (shown by the dotted line in Figure 4b).

Figure 4b suggests that the ideal condition for organizations to realize business value from DDS investments when commitment of data-driven management is low is to have a low-agility resource allocation process. Conversely, when

¹⁶ See Appendix 2 for details of the survey data analysis. Additional details can be obtained from the authors.

¹⁷ See the Data Analysis section of Appendix 2 for an explanation of how Figure 4 was constructed.

Figure 4: Joint Effects on DDS Business Value of Resource Allocation Process Agility with (a) Platform Maturity and (b) Commitment from Data-driven Top Management



ARAP = agility of the resource allocation process

commitment from data-driven management is high, a high-agility resource allocation process is appropriate.

In summary, the survey findings depicted in Figures 4a and 4b indicate that with low platform maturity and low commitment from data-driven management, an agile resource allocation process allocates resources inefficiently and results in line managers pursuing DDS projects that realize limited business value. With these conditions, a more centralized and formalized resource allocation process (i.e., a low-agility process) prevents line managers from investing in DDS-based projects that provide limited business value.

As an organization makes its resource allocation process progressively more agile, line managers accumulate both tacit and experiential knowledge that will enable them to invest in DDS-based innovations that will realize higher levels of business value. An agile resource allocation process is preferable when maturity of the platform and commitment from data-driven management are both high because line managers are more likely to identify high payoff DDS-based innovations and execute them successfully.

A Four-step Sequence for Realizing Value from DDS Investments

The case studies and survey findings show that firms are able to realize substantial business value from digital data initiatives, and we have identified the success factors that influence the outcome of DDS investments. However, the effects of the success factors are not straightforward, and complex combinations of organizational interventions are required to realize business value from DDS investments. It is not simply a matter of having all the success factors in place. Our research has shown that the sequence in which the success factors are put in place is perhaps even more important. As the patterns shown in Figure 4 indicate, a suboptimal combination of success factors can even result in lower business value. Based on our research findings, we present below the sequence of steps that will most likely lead to DDS investments that provide high levels of business value while reducing the possibility of making poor investment choices.

Step 1: Top Management Engages with Line Managers to Explore and Evaluate DDS Innovations

Entrepreneurial efforts of line managers in exploring and evaluating DDS innovations are the starting point for realizing business value from DDSs. Our findings show that the effort that line managers expend on exploring and evaluating potential DDS innovations depends significantly on the actions of top management in supporting the strategic use of DDSs and data-driven insights.

Respondent line managers in our survey held an average of four to six meetings over a six-month period with their top management to discuss potential data-driven innovations and engaged in a further two to three meetings per month to monitor the progress of DDS innovation projects. Our findings also show that when commitment from data-driven top management increased from low (organizations below the median) to high (organizations above the median),¹⁸ the effort expended by line managers on exploring and evaluating DDS innovations increased by about 40%. The number of hours spent by line managers discussing potential innovations with their direct reports also increased by 100% (from 7 to 14 hours per month), and the number of meetings that line managers had with their direct reports went up by about 110% (from an average of 2.5 to 5.5 meetings per month). These findings show that the extent of commitment by top management has a strong impact on the level of attention given to DDSs.

The efforts of line managers are strongly related to business value. Those in high-performing organizations spent a considerably larger proportion of their time on exploring and evaluating DDS innovations compared to those in low-performing organizations (8% vs. 18%, an increase of 125%).

A key implication of our findings is that top management and line management need to jointly embrace advances in digital technologies and actively engage with each other to build a culture of exploring, evaluating and pursuing DDS innovations. Organizations could consider

appointing senior executives who understand the potential of DDSs and business analytics technology platforms to create a culture that enables the realization of business value from DDS innovations.

Step 2: Line Managers Engage with the SDD Support Team to Understand the Potential Business Value of DDS Innovations

Line managers' efforts to exploit DDS innovations are significantly influenced not only by top management actions, but also by the level of engagement with a specialist digital data (SDD) support team. This team assists line managers in a variety of ways, including running pilot projects and demonstrating the business value that specific innovations could create, or developing specific DDS-based products or services that generate new revenue streams.

Line managers who responded to our survey held, on average, five meetings a month and spent 12 hours per month with their SDD support team analyzing potential innovations. Line managers in organizations with the highest level of engagement between line managers and the SDD support team spent about 60% more time with the team than those in businesses with the lowest level of engagement (11 hours per month vs. 7). Moreover, they held about 67% more meetings on DDS-based innovations with their direct reports (5 meetings per month vs. 3). We also found that line managers in organizations that realized high business value from their DDS investments were better supported by their SDD support teams than those that realized low business value (about 40% more value).

Step 3: Invest in Building a More Mature DDS Platform

By itself, the maturity of the DSS platform does not have a strong effect on realizing business value but does in conjunction with other success factors. Specifically, the maturity of the platform needs to grow in line with increasing agility of the resource allocation process and increasing commitment from data-driven top management. A high level of platform maturity won't deliver business value in the absence of other enabling conditions.

¹⁸ Organizations were categorized as "low" or "high" based on the median splits of the particular construct's value—i.e., values below the median were categorized as low and values above the median were categorized as high.

Our findings show that, in organizations with high platform maturity and high commitment from data-driven top management, line managers' efforts to innovate were about 30% more than those with low platform maturity and low management commitment. More importantly, the business value realized from DDS initiatives by organizations with both high platform maturity and high commitment from data-driven management was about 30% higher compared to organizations that were low on both. An understanding of those joint effects is important for organizations that seek to maximize the business value from their DDS investments.

Step 4: Make the Resource Allocation Process Progressively More Agile

Our findings show that the highest levels of business value were realized when high levels of both platform maturity and commitment from data-driven top management were complemented by an agile resource allocation process (see Figure 4). When the platform is reasonably mature and management actions reflect a high level of commitment to DDS innovations, organizations need to make the resource allocation processes progressively more agile to realize the most business value from DDS investments.

However, our data shows that when maturity of the platform is low, a high-agility resource allocation process *decreases* business value by about 15%. And when commitment from data-driven management is low, a high-agility resource allocation process decreases business value by about 14%.

A key finding from our research is that increasing the agility of the resource allocation process when both platform maturity *and* commitment from data-driven top management are low can reduce the business value realized from DDS investments by about 30%. Organizations should therefore persevere with a low-agility resource allocation process until the other enabling conditions are in place.

Decision Tree for Realizing Business Value from DDS Investments

Senior managers face pressures to deliver business value from their DDS investments. Our research reveals that success factors, such as platform maturity, the agility of resource allocation processes, the level of commitment from data-driven top management, the level of SDD team support and line management efforts, influence the business value created from DDS investments. In practice, the extent to which those success factors are present at any given point in time will vary by organization. Hence, each organization will need to design the set and sequencing of the organizational interventions needed to create the best conditions for realizing business value from DDS investments. In other words, there will likely not be a universal path to creating value, and firms will need to design their own paths taking into account the specific prevailing conditions.

To assist managers in designing an appropriate set of success factors for their particular situation, we provide below a simple diagnostic tool based on a decision tree (see Figure 5). This tool can be used to guide managers in sequencing their interventions. To illustrate, we consider below four scenarios that senior managers might face.¹⁹ Our starting point is whether managers consider DDSs as a valuable resource to improve firm performance.

Scenario 1: Little Investment in DDS Initiatives and Line Managers Do Not Actively Engage with their SDD Support Team

This scenario poses many challenges for organizations. The primary challenge is that DDS initiatives are not valued by the business. The required investment in platforms has not been made, and there is a lack of commitment to develop the technically competent teams needed to support line managers. In the absence of that support, attempts to educate line managers and demonstrate the benefits of DDS-based initiatives to enable value creation will likely not be successful. Thus, investments to create a mature

¹⁹ Each scenario has been simplified for the sake of clarity.

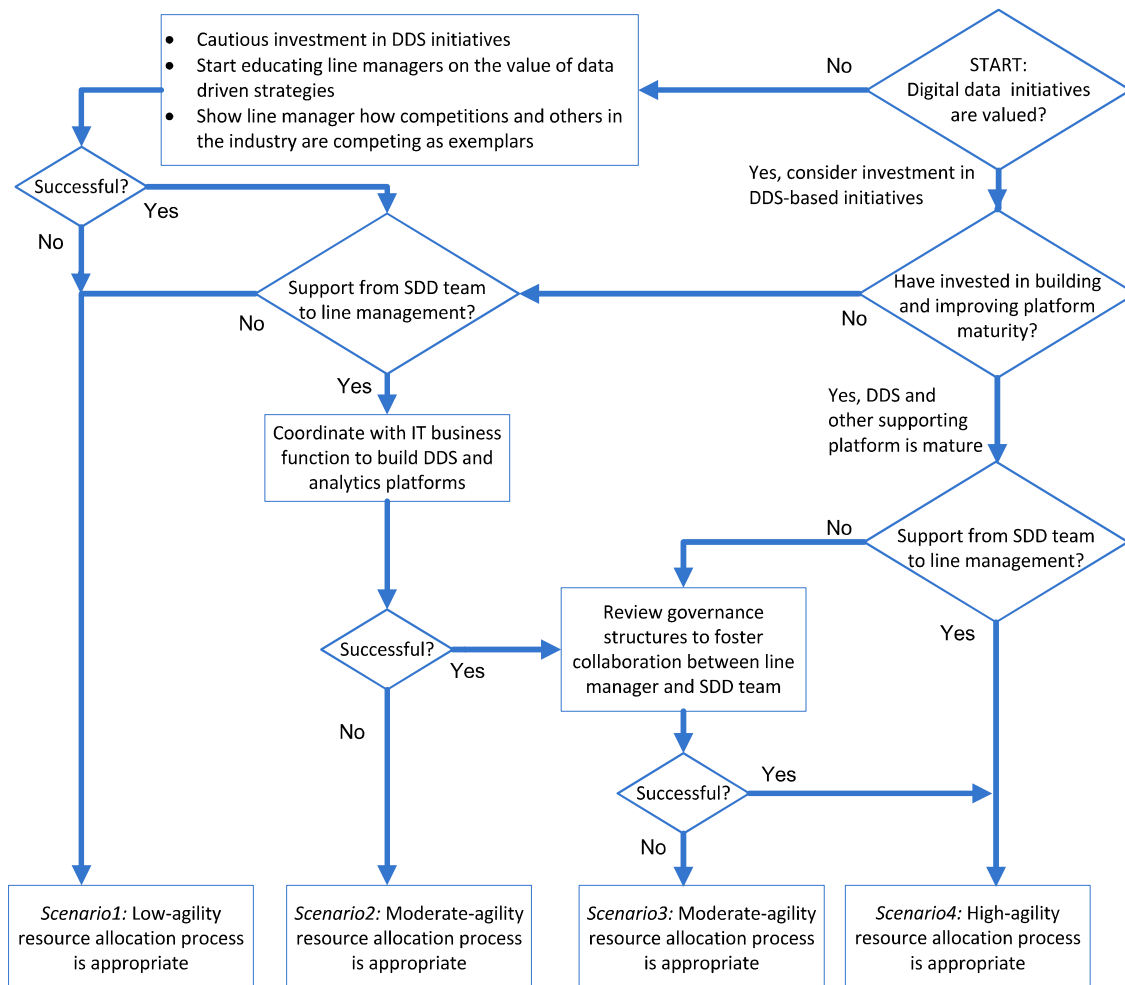
platform should proceed with extreme caution. Our findings shed light on how to create value from DDS innovations in Scenario 1. Specifically, top management and the SDD support team need to work closely with line managers to engage continuously in exploring and evaluating DDS innovations. In this scenario, cultural issues are dominant, rather than technological issues. A low-agility resource allocation process is most appropriate for this set of conditions. This type of process will ensure that firms do not make too many bad DDS investments.

Recommendation: *Highly formalized and centralized resource allocation processes are the best option. Invest in creating line management capability and structures for interactions between line managers and the SDD support team.*

Scenario 2: Little Investment in DDS Initiatives but Line Managers Actively Receive Support from the SDD Support Team

In this scenario, firms have made little investment in creating mature platforms, but SDD support teams have a high level of competence, and line managers are well supported by the teams. The strategy in this scenario should therefore be twofold: (1) continue investing in developing the capabilities of the SDD support team and (2) ramp up investment in the DDS infrastructure to create a mature platform. The resource allocation process for DDS innovation capital that best supports this strategy is moderately agile. This strategy and resource allocation process will enable line managers

Figure 5: Diagnostic Framework for Identifying Organizational Interventions to Realize Business Value from DDS-based Innovations



and the SDD support team to work together and develop the social and relational capital to lay the groundwork for future success by delivering positive outcomes from DDS innovations.

Recommendation: *A moderately agile resource allocation process is the best option. Also, invest in improving the maturity of the platform, the competencies of the technical support team and the DDS skills of line managers.*

Scenario 3: Considerable Investments in DDS Initiatives but the SDD Support Team Does Not Have Extensive Interactions with Line Managers

In this scenario, DDSs are valued, and the firm has invested heavily in creating a mature platform, but the SDD support team is not actively engaging with line managers. Organizations in transition can often suffer from this issue. This situation may arise when the motivations of the SDD team do not align with the motivations of other business functions. The misalignment might stem from inconsistencies between the key performance indicators used to evaluate the two functions. Organizations facing this situation should review the governance structures and policies that may discourage the two functions from interacting with each other. They will need to experiment with ad hoc governance structures aimed at institutionalizing positive interaction between the two functions. During the transition period to achieving institutionalized cooperation, organizations should maintain a moderately agile resource allocation process for DDS investments.

Recommendation: *Invest in creating line management capability and structures for interactions between line managers and the SDD support team. A moderately agile resource allocation process is appropriate, which should be made progressively more agile as line managers and the SDD team start working closely together.*

Scenario 4: Considerable Investments in DDS Initiatives and the SDD Support Team Provides Strong Support to Line Managers

This is the most ideal scenario. DDSs are valued, the firm has invested heavily in creating a mature platform and has highly competent digital data specialists who actively engage with line managers. In this scenario, an agile resource

allocation process is the most appropriate option, which will enable well-developed proposals for potentially successful DDS innovations to be generated at a much faster rate than would be possible with a bureaucratic process. An agile resource allocation process allows resources to be quickly allocated to high payoff DDS innovations emerging from the interaction between business functions and the SDD support team. In fast-moving industries where the pace of innovation needs to be high, there are clear benefits in reducing the latencies in “time-to-insight” and “time-to-exploit.”

A key finding from our research is that the agility of the resource allocation process is key to creating value from investments in DDS initiatives. However, although Scenario 4 is the ideal, our research and consulting work shows that only a small number of organizations are in this situation.

Recommendation: *A high-agility resource allocation process is the best option.*

Concluding Comments

The business value that can be realized from DDS investments has been clearly articulated in prior studies.²⁰ Many organizations, however, experience difficulties in realizing value from their DDS investments. Our research shows that the agility of the resource allocation process has an important influence on realizing value from such investments. Importantly, the influence of this process operates in conjunction with other key success factors—in particular the maturity of the DDS platform and the extent of commitment from data-driven top management. Our findings provide organizations with actionable interventions they can make to realize business value from their DDS investments. We find that while an agile resource allocation process is important for realizing value, organizations should make this process progressively more agile in line with increases both in platform maturity and in the extent of commitment from data-driven management. Based on our findings, we have presented a four-step sequence of organizational interventions and a diagnostic tool that will help organizations to realize value from their DDS investments while minimizing the risk

20 Pigni, F., Piccoli, G. and Watson, R. T., op. cit., 2016.

of poorly performing DDS applications resulting from adopting an agile resource allocation process in inappropriate conditions.

Appendix 1: Description of Survey Constructs

Business value: The extent to which organizations are able to realize value from their DDS investments. The survey was designed to measure business value on two key dimensions: performance and innovation. Performance is the extent to which DDS innovations enhanced an organization's financial performance. Innovation is the extent to which the organization introduced DDS innovations.

Agility of the resource allocation process: The ease with which line managers are able to obtain resources for DDS-based innovations. The survey measured two key aspects of the agility of the resource allocation process: the levels of centralization and formalization. Centralization is the degree to which decisions for sanctioning organizational resources for DDS innovations are concentrated with senior management; formalization is the degree to which line managers need to proceed through formal channels to obtain organizational resources for DDS innovations.

Platform maturity: The extent to which an organization has implemented the four key capabilities in its DSS platform: data management capability is the extent to which the platform enables the extraction, transformation and integration of multiple DDSs; systems integration capability is the extent to which the organization is able to seamlessly integrate data from multiple static and real-time sources; reporting and visualization capability is the extent to which the platform's reporting and data visualization tools enable the exploration of insights from DDSs for value-creating innovation; predictive discovery capability is the extent to which the platform enables the use of advanced analytics to proactively discover new insights and to predict future patterns and trends.

Commitment from data-driven top management: The extent to which top management undertakes actions to support DDS innovations. The survey measured four key sets of managerial actions that reflect the level of

commitment: resource support is the extent to which top managers committed resources (time/personnel/financial) outside the formal processes to support DDS innovations; vision support is the extent to which top managers communicated the strategic importance of DDS innovations for creating value for the organization; support for change is the extent to which top management changed existing norms and practices to support DDS innovations; monitoring support is the extent to which top managers were personally involved with their direct reports on DDS innovation projects.

Line management efforts to explore and evaluate innovations: The extent to which line managers invest their own time and discretionary resources available to them for exploring and evaluating DDS-based innovations.

Specialist digital data (SDD) team support: The extent to which an organization's SDD team engages with line managers to explore and evaluate DDS innovations.

Appendix 2: Survey Development, Validation, Administration and Data Analysis

Survey Instrument Development: We developed and validated the survey instrument following the guidelines in the literature for developing valid and reliable instruments.²¹ Each construct was conceptually defined prior to identifying items to measure the construct. For *agility of resource allocation processes, data-driven top management, platform maturity* and *business value*, we adapted items validated in prior research. For *managerial efforts to explore and evaluate innovations* and *support from specialist digital data team*, we drew on items from prior literature. The items for measuring the constructs were adapted and written as single idea statements. To reduce the effect of common

21 Coltman, T., Devinney, T. M., Midgley, D. F. and Venaik, S. "Formative Versus Reflective Measurement Models: Two Applications of Formative Measurement," *Journal of Business Research* (61:12), 2008, pp. 1250-1262; MacKenzie, S. B., Podsakoff, P. M. and Podsakoff, N. P. "Construct Measurement and Validation Procedures in MIS and Behavioral Research: Integrating New and Existing Techniques," *MIS Quarterly* (35:2), 2011, pp. 293-334.

method bias,²² where possible we employed open-ended numerical scales and behavioral measures (e.g., *how many meetings, how many hours, how many projects, how much money was spent*, etc.). Where respondents provided the stock ticker of their organizations, we used archival measures of financial performance to test the validity and reliability of their assessment of business value.

Survey Validation: The survey instrument was refined using a focus group interview with three academics with expertise in this research subject and in measurement theory. The refined instrument was then evaluated by three IT managers to assess content validity and to identify items that may be ambiguous or unfamiliar to practitioners. Following these refinements, the initial instrument was pre-tested in separate interviews with four additional IT managers.

We pilot tested the instrument in two separate web-based surveys using two different presentation formats. The data from the pilot tests was analyzed to assess the instrument for clarity, length and structure, for any potential technical glitches (e.g., spams filters, mail server filtering) and for methodological concerns (e.g., anonymity issues). The pilot test analysis also provided an initial assessment of the measurement properties of the instrument. The reliability of the responses was above acceptable values.

Survey Administration: The survey was administered jointly with our industry partner (SAS Institute Australia). Potential respondents were identified by the industry partner using its contact lists, which included clients and non-clients. Job titles of potential respondents were examined by two of the authors to ensure that they included only line managers. The survey was open for a period of about 10 weeks, during which one email reminder was sent. We received 72 completed responses.

Survey Data Analysis: We employed linear least squares regression analysis to test for the joint effects on business value of agility of the resource allocation process with platform

maturity and with commitment from data-driven top management. Following guidelines from prior research for testing two-way interaction effects,²³ we first centered the predictor variables to avoid any multicollinearity²⁴ issues and to overcome any biased estimates. The two interaction terms were then constructed by multiplying the centered values of the agility of the resource allocation process with the centered values of the other two predictor variables—platform maturity and commitment from data-driven management. The results from the analysis showed significant effects²⁵ on business value resulting from the interaction between agility of the resource allocation process and platform maturity, and between agility of the resource allocation process and commitment from data-driven top management support.

The results of the interaction effects are represented in Figures 4a and 4b of this article. To split the responses into organizations with low- and high-agility resource allocation processes, we categorized the values of the resource allocation process above the median value as “high” and those below the median value as “low.” The anchors for the x-axes in Figures 4a and 4b are scaled to range from -10 to +10, with a mean value of zero.

22 Sharma, R., Yetton, P. and Crawford, J. “Estimating the Effect of Common Method Variance: The Method–Method Pair Technique with an Illustration from TAM Research,” *MIS Quarterly* (33:3), 2009, pp. 473–490.

23 Aiken, L. S., West, S. G. and Reno, R. R. *Multiple Regression: Testing and Interpreting Interactions*, Sage, 1991; Cohen, J., Cohen, P., West, S. G. and Aiken, L. S. *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*, Routledge, 2013.

24 For an explanation of multicollinearity, see (for example) <https://onlinecourses.science.psu.edu/stat501/node/343>.

25 The effect size between the constructs was significant at the conventional acceptable level of $p < 0.05$.

Appendix 3: Survey Instrument to Measure the Constructs

Constructs²⁶ and Dimensions (Cronbach's Alpha)²⁷

Business Value (Cronbach's Alpha=0.93):

Performance

1. My unit was able to capture operational efficiencies based on ...
2. My unit was able to improve the performance of its distribution channels as a result of ...
3. ... has contributed significantly to improving the performance of my unit
4. ... generated significant value for my unit

Innovation

5. My unit has introduced a number of new services based on ...
6. My unit has been able to promote our products/services to new customer segments ...

Agility of the Resource Allocation Processes (Cronbach's Alpha=0.85):

Centralization

1. I need to consult my managers before I allocate resources to ... projects
2. If I need resources to exploit ... insights, I need to get an approval from my managers
3. My manager has to consult his/her superiors before committing any resources to ... projects

Formalization

4. In my organization, there are established rules and procedures for allocating resources for projects
5. My organization strictly follows rules and procedures for allocating resources
6. I need to write a formal proposal to request any resources for ... projects

Platform Maturity (Cronbach's Alpha=0.85):

Measured on a five-point scale ranging from 1=non-existent to 5=optimized, with 5 indicating a fully enhanced analytics capability.

- *Data Management Capability*: ... extracts, integrates and converts data from multiple sources
- *Systems Integration Capability*: The extent to which your organization seamlessly integrates data from various operational systems into your ... systems
- *Reporting and Visualization Capability*: The extent to which your organization utilizes reporting and data visualization tools to ...
- *Predictive Discovery Capability*: ... uses advanced analytics to proactively discover new insights and to predict future patterns and trends

Scale:

1 = *Non-existent*: the organization does not have this capability

2 = *Initial*: the capability exists but is poorly developed

3 = *Intermediate*: the capability is well developed, but there is much room for improvement

4 = *Advanced*: the capability is very well developed, but there is still a little room for improvement

5 = *Optimized*: the capability is so highly developed that it is difficult to envision how it could be further enhanced

²⁶ All survey items were based on previously validated measures reported in the academic literature.

²⁷ Cronbach's alpha is a measure of internal consistency—i.e., how closely related a set of items are as a group. It is considered to be a measure of scale reliability. A "high" alpha value does not imply that the measure is unidimensional

Extent of Commitment from Data-driven Management (Cronbach's Alpha=0.90):

1. In the last year, my manager has committed substantial resources (time/personnel/financial) to ...
2. Committing resources for the success of ... projects has been a priority for my manager in the last year
3. Number of ... projects approved by your manager in the last year*
4. My manager has clearly explained to my unit the strategic value of ...
5. My manager has frequently articulated the importance of ... for improving performance
6. My manager employs my use of ... as a key performance indicator for evaluating my performance
7. My manager has encouraged me to employ the use of ... as a key performance indicator for evaluating the performance of my direct reports
8. My manager has regularly provided constructive feedback on the progress of ... projects
9. My manager personally monitors the progress of ... projects

Line Managers' Efforts to Explore and Evaluate Innovations (Cronbach's Alpha=0.86):

1. How many hours (approximately) have you spent with your direct reports in the last month searching for ...
2. In the last six months, on average, what percentage of your time (approximately) have you spent searching for ...
3. In the last six months, how many projects have you initiated ...*
4. How many hours have you spent in the last month analyzing ...
5. In the last month, how many meetings have you held with your direct reports to discuss insights ...
6. In the last six months, how many projects have you initiated that exploit insights ...*

Support from Specialist Digital Data Team (Cronbach's Alpha=0.90):

1. My ... team has clearly communicated to my unit the types of insights that they could generate using ...
2. My... team has adequately demonstrated to my unit the value that ... can deliver for my unit
3. My... team has clearly communicated to my unit the success it has delivered in other parts of the organization
4. In the last year, on average, how many hours has each of your direct reports spent being trained on ...*
5. ... team in my organization encourages business users to undertake advanced training programs
6. ... team in my organization provides the necessary training for business users
7. How many hours did you spend in training sessions to learn#... in the last year*

*Responses to these items are captured on open-ended numerical scales.

Appendix 4: Demographics of Survey Respondents

The target respondents were managers, senior managers and executives in various line management functions, such as general management, human resources, marketing and finance. IT managers were specifically excluded from the survey.

Industries: The respondents came from banking and finance (23%), government (15%), information and communications technologies (14%), utilities (8%), hospitals and medical (7%), manufacturing and retail (6%), public services (3%), transportation (1%) and other (23%).

Organizational role: All respondents were line managers with job titles that included manager (45%), director (17%), senior manager (9%), coordinator and lead (6%), consultant (2%) and other (21%).

Role experience: Respondents had a mean experience of 7 years, with the minimum being 0.5 years and maximum being 32 years. Approximately 25% of managers had less than 2.5 years of experience, 17% had between 2.5 and 5 years' experience, 26% had 5 to 10 years' experience, 6% had 10 to 15 years' experience, 1.5% had 15 to 20 years' experience, and 6% had more than 20 years of managerial experience.

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