Harnessing Abundant Data to Create an Intelligent Manufacturing Enterprise
The manufacturing sector in many ways sowed the seeds for the digital transformation of industries. Building on the automation of production from the computing age, the fourth industrial revolution brought digital technologies into the factory. This has since pervaded all aspects of business leading to a radical reimagination of economic activity. We at TCS termed this phenomenon as Business 4.0™.

At the center of this is the manufacturer, for whom data has exploded at multiple levels – the product, enterprise, and ecosystem. Even before the emergence of large-scale internet of things (IoT)-based systems, aircrafts generated terabytes of data for each flight, process plants recorded production data captured in ‘plant historians’ and control systems, and industrial equipment captured performance data through their duty cycles. Sensor data magnified this exponentially by turning terabytes into petabytes.

Today, automobile firms, airlines, and factories process vast amounts of data. The products and services they offer provide in-depth information about their users by presenting behavioral patterns. However, enterprises are still grappling with the best strategies to harness this surfeit of data and are often left with deep insights in siloed parts of their businesses. This paper looks at how manufacturing companies can master this data abundance to create a data-centric operating model and become an intelligent enterprise.
The Challenge of Harnessing Abundant Data

In the traditional linear manufacturing value chain, each enterprise executes different activities—from design, procurement, and production, to selling and servicing of products, now bundled with services—to create differentiation in the products or drive cost-based advantages. In the new data-driven economy, manufacturers can gain competitive advantage through collaboration, not only within the enterprise but also across the ecosystem, which is now part of the extended value chain. Smooth data flow across the ecosystem is an important enabler of collaboration, giving rise to the creation of data products.

While data is available aplenty (see Figure 1), most organizations struggle to harness it effectively. This is due to lack of data standardization, quality, harmonization, exchange formats, regulatory rules, and well-defined and universally accepted data ownership guidelines.

Additionally, data from connected devices may contain sensitive, confidential, or personally identifiable information (PII). Organizations must safeguard such data to protect privacy, adhere to regulations such as the General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA), and maintain confidentiality. Besides, organizations must factor in concerns regarding data security, costs, and storage of huge volumes of data. There is a strong need to overcome these issues by fostering faith among stakeholders across industries, agencies, and governments that will harvest the abundantly available data. This will subsequently create innovative services, cut down costs and effort, and create exponential value through partnership.

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1. IDC; Worldwide Global DataSphere IoT Device and Data Forecast, 2019–2023; May 2019.
Enterprises are able to offer personalized products and services—an important facet of the Business 4.0 era—by effectively harnessing abundantly available data. They are able to do this by bringing together digital technologies and capabilities, thus ensuring they gain competitive advantage. Besides, the ecosystem partnerships that manufacturers have formed facilitate new business models, which allows them to deliver exponential value to their customers.

Manufacturing business segments have long and complex value chains. Enterprises can create value in this data-driven economy by obtaining information from multiple sources—from smart intelligent products; from within the enterprise, as in the case of enhancing safety inside plants; across the value chain, as in the case of connected cars; and across industries, as in the case of airlines (as aircraft operators). This potentially places manufacturing in a unique position among other comparable industries. To better understand this, it is important to know how manufacturing firms harness data from the various information sources.

In our recently conducted Business 4.0 research, we have identified the factors critical for harnessing data and the barriers that prevent it (see Figure 2 for manufacturing sector specific findings). While a majority of respondents in the survey said data offers them insights, there is still a need to overcome data security, risks, and regulatory boundaries.

![Figure 2: Prerequisites to harnessing data and the barriers preventing it](image)

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### Top barriers to monetize transaction data

<table>
<thead>
<tr>
<th>Barrier</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risks to data security</td>
<td>36%</td>
</tr>
<tr>
<td>Data protection laws</td>
<td>27%</td>
</tr>
<tr>
<td>Lack of senior leadership buy-in</td>
<td>20%</td>
</tr>
<tr>
<td>Industry regulation</td>
<td>19%</td>
</tr>
<tr>
<td>Outdated technology</td>
<td></td>
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<tr>
<td>Lack of clear business case</td>
<td></td>
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<tr>
<td>Dispersed data</td>
<td></td>
</tr>
<tr>
<td>No insights</td>
<td>12%</td>
</tr>
<tr>
<td>No skills in-house</td>
<td>12%</td>
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</tbody>
</table>

Intelligent Products

At the heart of this new data-driven manufacturing economy lies the intelligent product.

Manufacturers can generate business value by creating smart products that range from jet engines and mining equipment to consumer and home products such as toothbrushes and home printers. What is changing the business models of firms is the connectivity they offer. Sensors embedded in the products offer firms data-led insights into usage and provide personalized services to end users. Moreover, the products and the data they generate are deeply interconnected in the new economic model of value creation.

Intelligent Enterprise

While the traditional value chain captures enterprise data right from product design to manufacturing and aftermarket services, data harnessing has to go beyond this and capture information related to time-stamp production, asset performance, and end-user and usage context.

Enterprises must look beyond efficiency and optimization and focus on growth and transformation.

Democratization of data, or making data available to everyone, within the enterprise has multiple benefits as it can be accessed from a single source. The connected enterprise makes data available across various stakeholders, from suppliers to production and field usage, which is the source of innumerable insights for planning and execution. It creates value as it fuses enterprise systems data with real-time product data. To illustrate, manufacturers now offer service contracts and extended warranties for a charge, which create new revenue streams for them while ensuring that they deliver optimum performance and significant business outcomes.

Intelligent Ecosystem:
When Data Converges, Businesses Grow

The manufacturing ecosystem is increasingly becoming a part of the connected, purpose-driven value chain, and manufacturers can create value from the collaborative data-driven economy in multiple ways.

Collaborating partners need to factor in the business model, the target operating model, and commercial models when making decisions, as they will define how data products are created and shared. This requires cross-industry partnerships to ensure all partners gain from the adequate surplus.

A collaborative ecosystem comprises the following stakeholders:

- Enterprise, extended enterprise, and industry
- Supporting and controlling agencies—academia, startups, government agencies, regulatory bodies, data aggregators, data-led service providers, and advisory organizations
- Consumers of connected and intelligent products

Harnessing data must happen at the intersection of the enterprise, the value chain, and across industries, as Figure 3 illustrates.

Figure 3: Purpose-driven economic models at the intersection of the enterprise-extended value chain and industry ecosystem

To overcome the challenges of harnessing data, such as lack of quality and standardization, and to monetize it effectively, members of the ecosystem, who until now were just ‘tiered’ participants in the value chain, can create value based on the new services they can provide. This leads to the creation of data products.
Take, for example, the case of lightweight designs for electric cars. The material supplier for the body of the car has to reduce the overall weight of the car without compromising on its quality. Because of technology advancements, the parts can now be 3D printed, instead of going through the traditional manufacturing process of stamping a metal sheet to a desired shape. The performance of the materials under different operating conditions can lead to a continuous improvement cycle, including sharing data on usage patterns and operating environments. This value add not only reduces the cost of materials but also defines the performance characteristics of a vehicle, which ultimately impacts its market acceptance.

Figure 4 below demonstrates how emerging collaborative models can give rise to new services.
Operating Models of the Intelligent Enterprise

Organizations have a choice to make regarding their ‘data centricity’ and operating models, and this will depend on how strong their foundation is. Figure 5 depicts five key operating models, classified basis the potential returns they can deliver.

Enterprises must take a leap of faith and shift from operating in silos to embracing cross-industry partnerships, but it is not that simple. Besides technology, organizations need to make choices on both the business and target operating models, which align with the construct of the intelligent ecosystem discussed earlier. Along with data, two other crucial elements that stand out are the abundance of capital and talent.

Currently, firms are only dealing with individual assets or enterprise data, with data exchange and commercial monetization frameworks largely absent. In the connected ecosystem, firms need real-time assets and sensor data, user and usage context data, and social data as well, which has to be shared across the wider stakeholder community. To make this data available, a framework to facilitate resource sharing (within the scope of abundant data), while maintaining the competitive advantage of individual players, is needed (see Figure 6).

Figure 5: Data centricity and the operating models of enterprises

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Figure 6: The connected ecosystem
The potential anchors of a connected manufacturing ecosystem are as follows:

- **Industry leader as an ecosystem anchor**: An existing stakeholder in the emerging ecosystem has the advantage of understanding the market dynamics and drivers as well as what value data can create for the customer. By acting as the anchor, the player can attract complementary partners, including technology players, who can help develop new data-sharing platforms, evolve commercial models and market offerings, and ensure shorter time to market. As trust and faith develop, the participants grow and prosper. Such an ecosystem faces the challenge of attracting competitors on the same platform despite fears of eroding the business value proposition of the competing entities. However, industrial enterprises, which need considerable support for ‘data interpretation’ from original equipment manufacturers (OEMs), would certainly gain from having them as anchors.

- **Neutral players forming a ‘nucleus’**: This is typical of a startup-led incubation, which has no specific existing stake in the ecosystem, and is able to attract competing partners. Organizations can create value by forming a neutral platform involving multiple stakeholders. Typically, these platforms prosper when the data exchange is not bound by proprietary know-how.

- **Hybrid options**: Anchor players, seeking to form neutral open platforms, can create subsidiaries or spin off entirely new businesses, which can harness the best capabilities and degrees of freedom of both operating models.

**Case in point**: The automotive industry probably offers the best insight into how various ecosystems are shaping up. All three models are at work, with existing OEMs forming collaborative clusters, technology giants forming their own neutral platforms, and competitors collaborating with one another. This is especially so in the case of shared mobility, where the operating models can reach a critical mass quickly enough. The three models can also be used to harness the scarce resource pool of data scientists across the landscape and optimize the capex investment for standard features without reinventing the wheel.
Drivers of the Data-Centric Enterprise

The operating models that ensure data products are shared in the connected, data-led, insight-driven, and intelligent manufacturing enterprise are based on numerous motivations and opportunities (see Figure 7). In this complex and hyper-competitive environment, it is difficult not to adopt any of these models.

The varied sources of data in the manufacturing value chain are driving collaboration, thus ensuring that a framework exists for creating, sharing, mining and serving data. This refers to a ‘digital highway’. Besides ensuring that data flows freely, securely, and in real-time, this highway must be able to handle structured and unstructured data.

**Case in point:** Airlines do not operate in isolation but through an ecosystem of OEMs, engine suppliers, the maintenance repair and overhaul (MRO) industry, airports, regulators, air traffic controllers, service providers, ticketing agents, ground service personnel and more. Each entity has access to data or is generating it. Consolidating this data can create tremendous value, bringing all partners onto the same page.
Emerging Opportunities in the Business 4.0 Era

Traditionally, the manufacturing ecosystem operated under the hierarchy of enterprise, extended enterprise (value chain), and industry. Every manufacturing firm had been associated with academia, nonprofit advisory organizations, and government and regulatory bodies as supporting and controlling agencies. However, with the emergence of the data-led economy, data aggregators, big data managers, and data-led service providers have become stakeholders to each enterprise. The ‘customer’ or ‘consumer’, who now demands smart products bundled with services, propels this entire industrial ecosystem. This drives the need for more innovation and collaboration. This is also pushing manufacturers to create personalized products and services for their customers, which leads to higher profitability. The triangulation of assets and enterprise, customers and consumption, and ecosystem into a collaborative engagement model drives growth.

Findings from our Business 4.0 research have evinced the need for cross-industry collaborations across manufacturing enterprises. Industry leaders who have embraced more than one Business 4.0 behavior (driving mass personalization, creating exponential value, leveraging ecosystems, embracing risk) have experienced higher profitability, increased customer interactions, and an enhanced ability to develop innovative products and services, while being able to plan ahead to de-risk their business models (see Figure 8).

To be successful in this competitive context, firms would need to choose their data-centric operative models early on, align them to their prime motivation and growth drivers, and then carefully evaluate the environment to build and leverage the most appropriate collaborative ecosystem constellation.
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