

SURVEY REPORT

DATA MASTERY: A KEY TO INDUSTRIAL COMPETITIVENESS

FUTURE OF MANUFACTURING PROJECT

PROJECT SPONSORS



INTRODUCTION

Now in its third year, the Manufacturing Leadership Council’s “Future of Manufacturing Project” continues to focus on its main goal: to enable manufacturers to envision what manufacturing might look like by 2030. Achieving this goal entails thinking broadly about the intersection of the technology, organization and leadership trends shaping Manufacturing 4.0, the stage of industrial evolution based on the digitalization of manufacturing plants and factories. It also requires an intense focus on specific aspects of those trends to understand, at a deep level, the opportunities and challenges.

This research paper is part of the Project’s focus this year on what MLC calls “Data Mastery”—the ability to gather, organize, analyze and use information from all facets of manufacturing. Data Mastery produces step changes in efficiency, cost effectiveness and productivity. It enables better decision-making, while advancing new value creation and, ultimately, competitiveness. The white paper follows an event the MLC held in December 2023, called “The Coming Data Value Revolution.”

The one-day conference explored three key aspects of Data Mastery—data value, including data monetization and the use of data to drive data ecosystems; enabling technologies, such as artificial intelligence, visualization and industrial metaverse technologies; and people and processes, including data oriented job roles and data-driven cultures. In the second half of 2024, the MLC will continue with its focus on Data Mastery with webinars, case studies and additional research.

Please check the MLC website for updates and further information. The MLC team thanks its Future of Manufacturing Project partners—EY, NTT DATA, Invisible AI and West Monroe—for their support and for their invaluable feedback on the white paper.



EXECUTIVE SUMMARY

Core to Manufacturing 4.0's value proposition is the idea that data about all facets of operations can help create substantial improvements as well as identify new ways factories and plants are organized and run.

As factory and plant operations become increasingly connected electronically, the opportunities for data generation from machines and processes grow exponentially, offering ways to identify and resolve problems earlier, reduce downtime, raise efficiency levels, cut costs and enhance productivity and time to market. Moreover, as advanced technologies, such as artificial intelligence, are applied to large datasets processed by powerful computer systems, insights will be derived that enable manufacturing companies to innovate in products, processes and how people work.

That, at least, is the underlying theory about the role of data in manufacturing in the digital age.

While the aspirations are reasonable, the reality of today is that Data Mastery, as the MLC calls it, is a journey that can be long and often difficult for many manufacturers. While progress in leveraging data is being made by many manufacturers, organizing effectively around the data opportunity remains a work in progress for the industry, this white paper suggests.

The survey on which this white paper is based examined four major aspects of Data Mastery. They are data governance and organization, manufacturing data, business impact and future trends.

One of the most important findings from the study was that an overwhelming majority of manufacturers (86%) believe that the effective use of manufacturing data will be “essential” to their competitiveness. Another 14% said that data will be “supportive” for their competitiveness by 2030. Clearly, manufacturing leaders understand the role that data plays in enabling them to be flexible and agile in a time of seemingly constant disruption.

Other key takeaways from the survey:

- Although 61% say their companies have a corporate-wide governance plan for data, there is a gap between data strategy and overall business strategy. Only 15% say the two strategies are fully aligned, 31% indicate they are closely aligned and 25% say they are partially aligned.
- Senior leadership, say 58% of respondents, is responsible primarily for data governance and strategy, but only 22% say that responsibility is linked to annual incentives, KPIs or business imperatives.
- An exponential growth in data volumes is expected by 2030, with one-third of respondents indicating that the growth would exceed 500%. Another 18% see an increase between 200% and 500%.
- Although analytics tools are on the rise, a majority of manufacturers still use spreadsheets to analyze manufacturing data. Nevertheless, by 2030, the number of respondents expecting to be able to engage in predictive analytics will double.



- Less than half of respondents are using some kind of validated financial metric to demonstrate the value of their data. Instead, companies are using second-order metrics, including the impact on operational performance, as proxies for the value of data.
- The most significant challenge in advancing data-driven decision making, say 53% of respondents, is coordinating data from different systems in their companies.

As manufacturers proceed on their data journeys and look forward to 2030, solving the organizational issues evidenced in the study will be central to their ability to maximize the value from the data they are collecting about operations. The first step in this process is understanding the inconsistencies and the tension points arising from being a data-driven business.

Data Mastery will be achieved when that understanding leads to workable solutions successfully applied. Only then will the promise of using data to both improve operations and find new and better ways of running plants and factories be realized.



SECTION 1

DATA GOVERNANCE AND ORGANIZATION

Data drives M4.0, which means that good, trusted data is critical. Manufacturers have been focused on managing aspects of data, but the scope and importance is escalating. What was once the sole responsibility of IT, data ownership at manufacturers is moving to shared responsibility with IT/OT while the responsibility for good data is moving to the business and senior leadership teams.

Data management includes traditional elements, such as data security and privacy, along with data quality and governance. Data security and privacy are considered essential business requirements, and survey respondents validate this. The continued rise of AI solutions is driving an increased focus on data governance and data quality, but companies are just starting to apply the same rigor here as they do on security and privacy.

More than 90% of respondents have a formal or partial policy on data security (Chart 1) and data privacy (Chart 2), which are now must-have requirements for the future. It is vital for companies to refresh and validate their processes continually.

ROUGHLY 95% OF MANUFACTURERS HAVE A FORMAL OR PARTIAL POLICY ON DATA SECURITY

Does your company have a formal policy on data security? (select one)

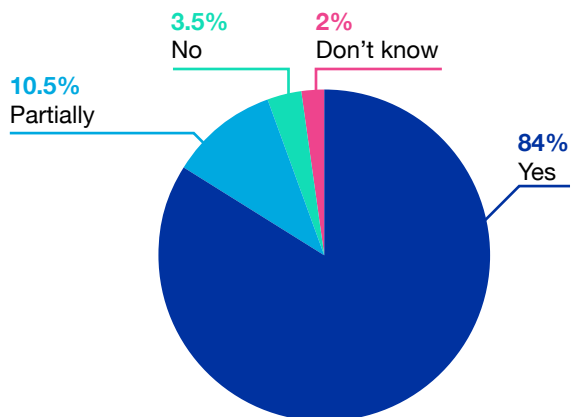


Chart 1

MORE THAN 90% OF MANUFACTURERS HAVE A FORMAL OR PARTIAL POLICY ON DATA PRIVACY

Does your company have a formal policy on data privacy? (select one)

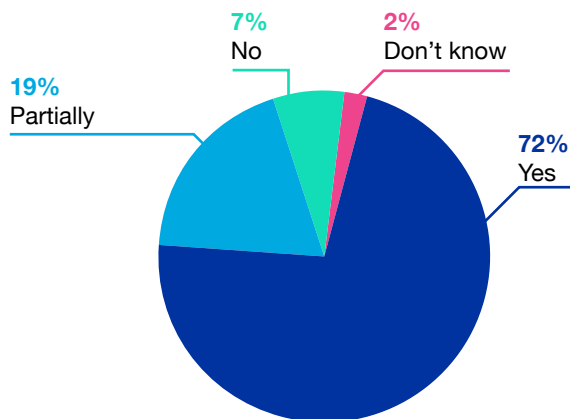


Chart 2

While data quality is recognized as essential, most companies do not have a formal policy around data quality and instead manage it through individual silos and systems. While this is a positive start, developing formal company-wide policies for data quality is vital if manufacturers want to realize the full potential of integrated datasets supporting activities such as digital threads and digital twins (Chart 3).

ABOUT TWO-THIRDS OF MANUFACTURERS HAVE A FORMAL OR PARTIAL POLICY ON DATA QUALITY

Does your company have a formal policy on data quality? (select one)

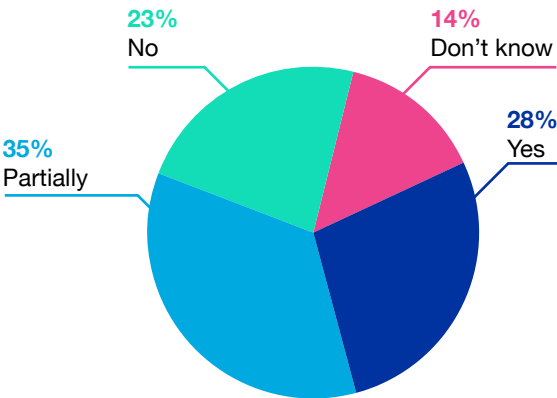


Chart 3



Meanwhile, more than 60% of respondents have a corporate-wide plan, strategy or guidelines for data management (Chart 4), but only 15% follow this entirely (Chart 5). Data management can include data governance, data literacy, analytics strategy and AI strategy. In many companies, these are still distributed activities managed at a functional or silo level. But this is changing as companies realize that to truly leverage data science skills, they need to start with data engineering and do a better job of collecting, organizing, accessing and utilizing data. And, as the survey shows, it is not enough to just have policies in place; companies need to have the processes, technology and skills in place to ensure these policies are being followed.

MORE THAN 60% OF MANUFACTURERS HAVE A PLAN, STRATEGY OR GUIDELINES FOR DATA MANAGEMENT

Does your company have a corporate-wide governance plan, strategy or formal guidelines for how data is collected, organized, accessed and utilized across the enterprise, including manufacturing operations? (select one)

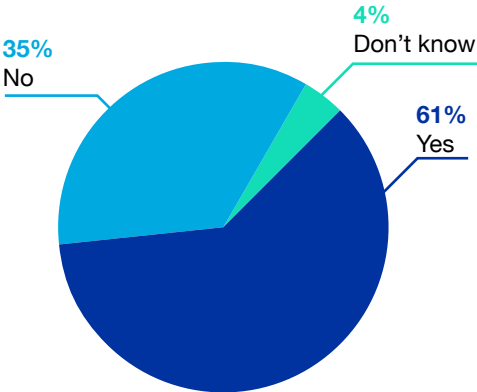


Chart 4

FEW MANUFACTURERS ALIGN BUSINESS STRATEGY ENTIRELY WITH DATA STRATEGY

If you answered yes to the previous question, how closely do you feel this data strategy is aligned to your company's overall business strategy? (select one)

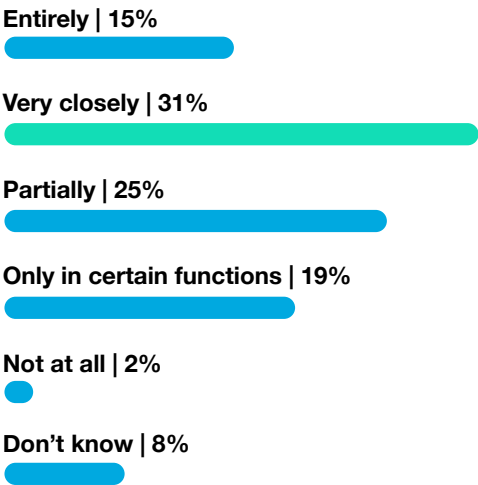


Chart 5

As the MLC has seen time and again, leadership plays one of the most vital roles in digital transformation, including data projects. Leadership has a mixed role with regards to data projects. A positive sign is that the majority of respondents assigned a C-suite leader with primary data governance responsibility (Chart 6). On the flip side, only 22% of companies have a direct connection from data activities to annual incentives, KPIs or business imperatives for their leadership team (Chart 7). Ultimately, there needs to be both distributed ownership through incentives, KPIs and business imperatives, while having a clearly defined leader responsible for data governance.

ALMOST 60% OF MANUFACTURERS POSITION DATA GOVERNANCE RESPONSIBILITY WITH SENIOR LEADERS

Who is primarily responsible for data governance and strategy in your organization?
(select one)

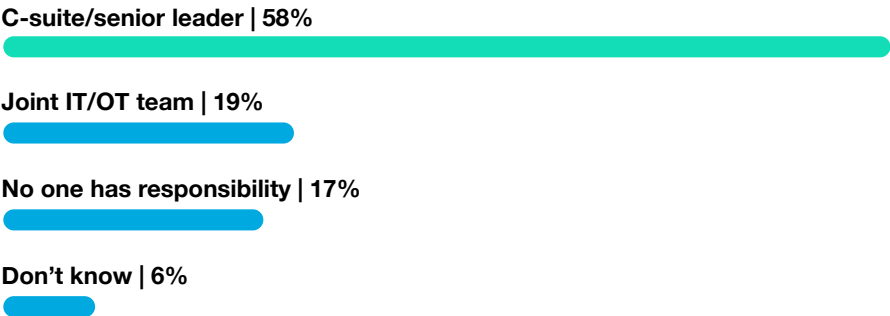


Chart 6

FEW MANUFACTURERS LINK DATA ACTIVITIES ENTIRELY TO INCENTIVES, KPIs

Is data collection/management/analysis included in annual incentives, KPIs or business imperatives for company executives/leadership?
(select one)

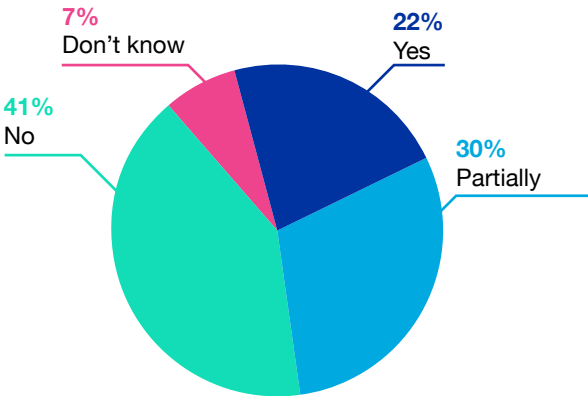


Chart 7

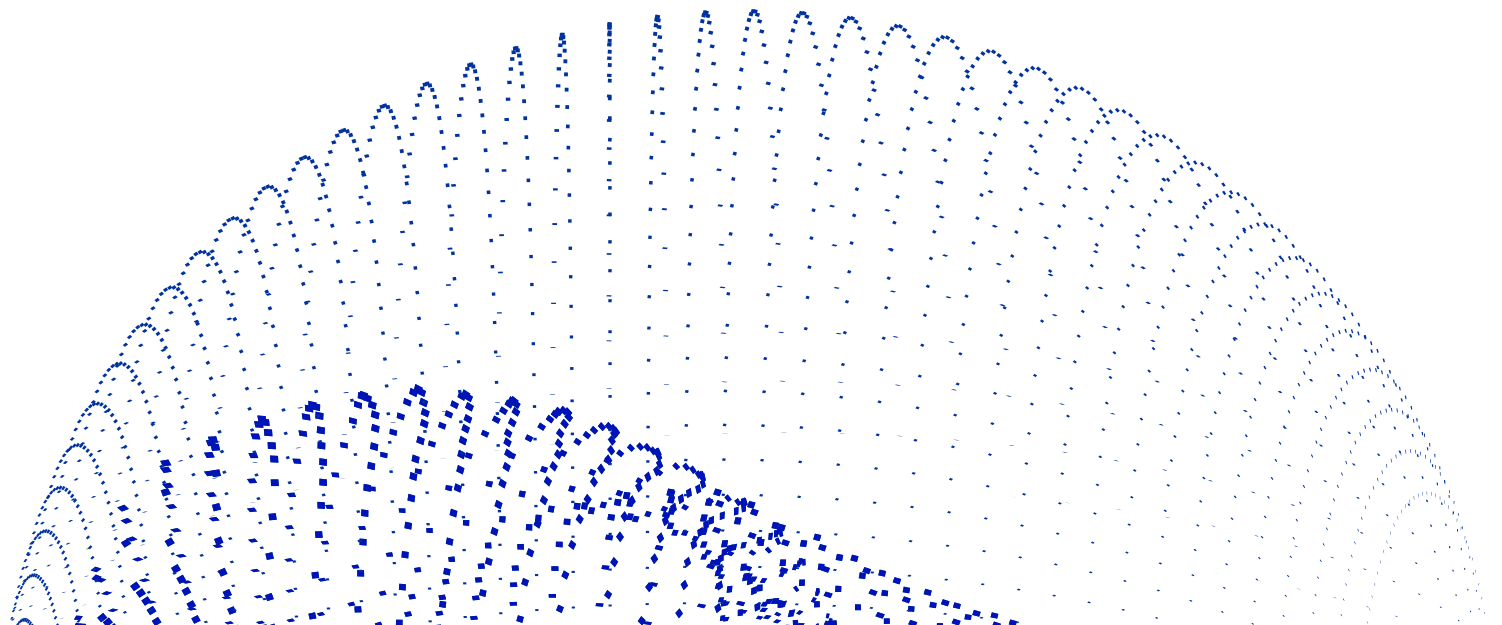
SECTION 2

MANUFACTURING DATA

As manufacturers advance along their M4.0 journey, data is becoming their lifeblood, driving operational insights and shaping decision-making. As the amount of data compounds, the industry is at a crucial juncture. Manufacturers are grappling with the challenges of collecting, analyzing and leveraging the abundance of data now at their fingertips. We are at a tipping point. The confluence of traditional and modern technologies and practices, alongside divergent data standards, are hurdles to harnessing fully the potential of the data that is being generated. It is important to overcome these obstacles now because survey respondents suggest data will be even more vital to manufacturing's future.

Despite advancements in technology, MLC research shows that a significant portion of manufacturers still rely on manual data entry (Chart 8), showcasing a gap between available data sources and their utilization; this is a notable area for improvement as the industry looks toward 2030.

Moreover, as traditional systems like PLCs, quality systems and ERP systems remain prevalent as data sources, newer technologies, including vision systems, AI, edge computing and digital twins, lag behind. While there is a recognition of these technologies' potential, barriers remain to their widespread adoption and integration within manufacturing processes, which can vary greatly from one organization to another and include elements such as cost concerns, availability of skilled workers, the need to integrate with legacy systems and organizational desire.



SEVENTY PERCENT OF MANUFACTURERS STILL ENTER AT LEAST SOME DATA MANUALLY

What are the sources
of your manufacturing
data today? (select all
that apply)

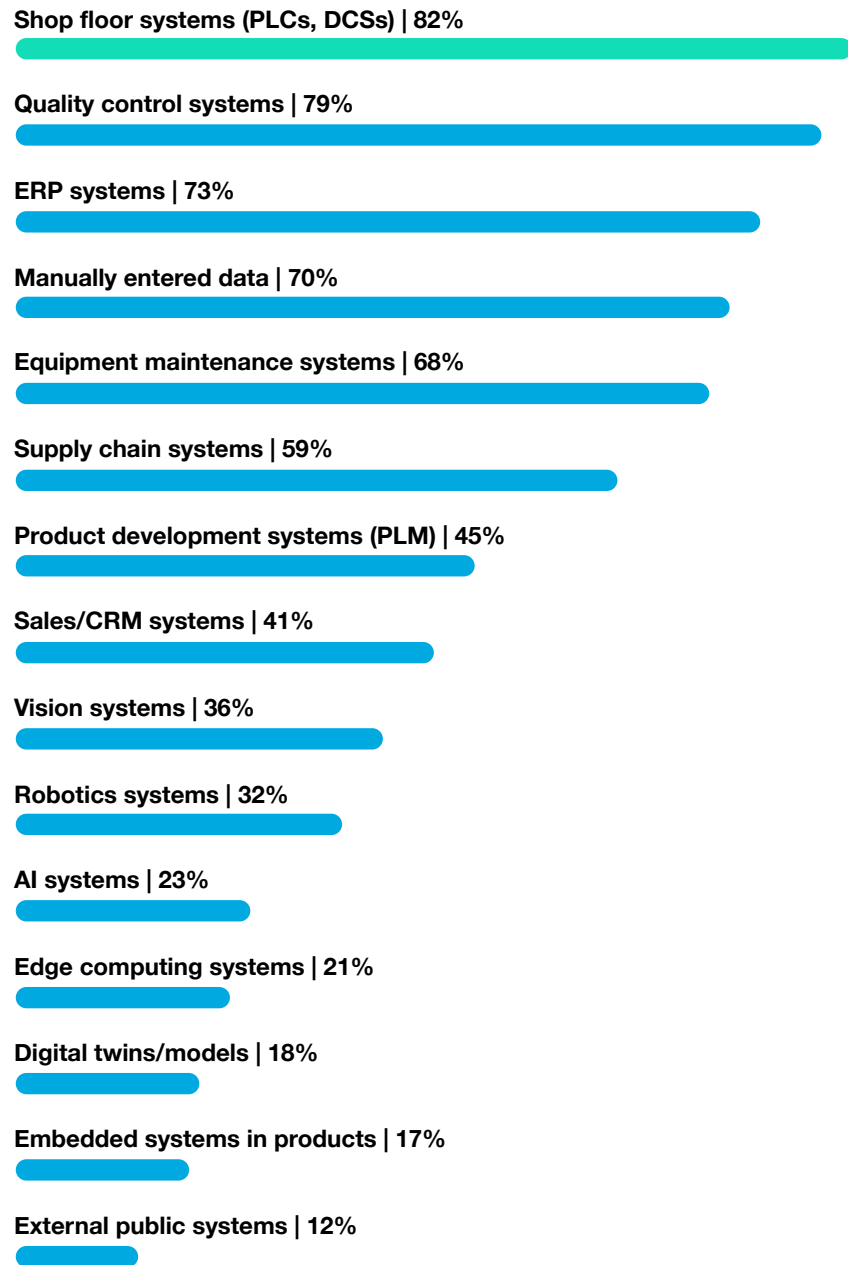


Chart 8

As use of these newer technologies becomes more prevalent, the number of data sources will continue to expand in manufacturing settings. As they do, widespread manual data entry will become a less sustainable option. As it stands, 44% of manufacturing leaders have seen at least a doubling of the amount of data they are collecting in their organization today compared to two years ago. Half of the leaders surveyed expect the data they collect to at least triple by 2030 (Chart 9).

**EXPONENTIAL
GROWTH IN DATA
VOLUMES IS
EXPECTED BY 2030**

What is the percentage increase in the amount of manufacturing data you are collecting today versus two years ago? What is the expected increase by 2030? (select top three)

- Today
- 2030

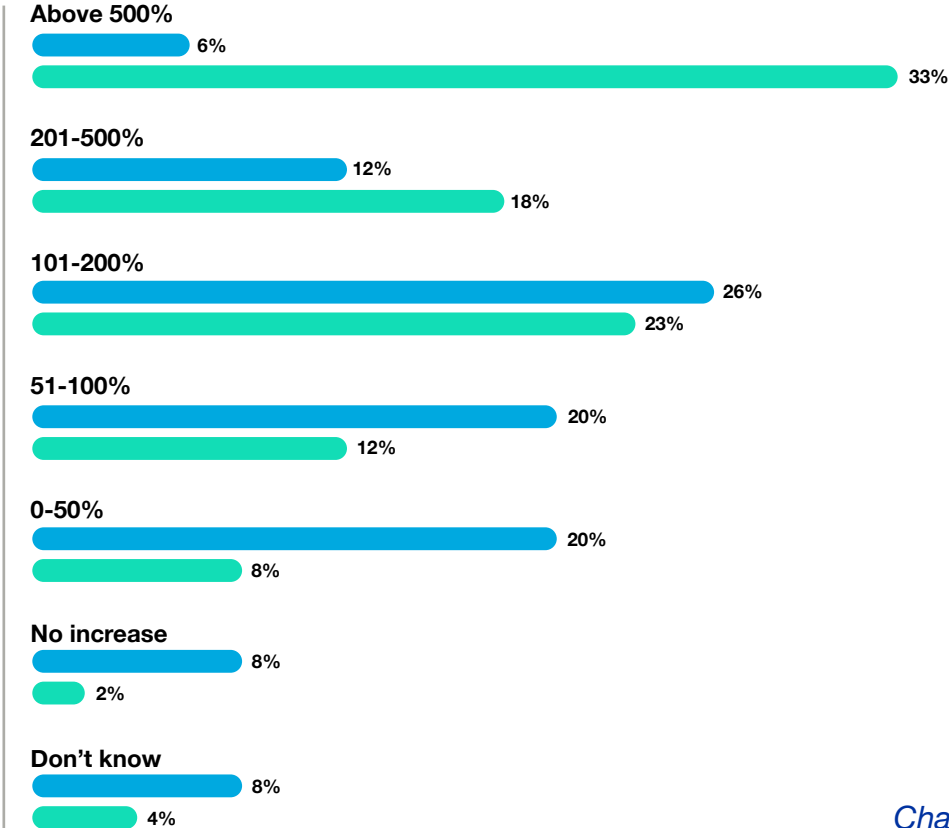


Chart 9

Looking ahead to 2030, the way manufacturing data is used will undergo a significant transformation. Nearly 60% of manufacturers today are focused on understanding and optimization projects, respectively. Although optimization will remain a primary objective in 2030—in fact, respondents believe it will grow in its importance—the survey indicates a shift toward increased use of manufacturing data to make predictions about operational performance, including machine performance, by the start of the next decade. This shift underscores the increasing emphasis on leveraging data not just for reactive insights but also for proactive decision-making and predictive analytics, aligning with broader industry trends toward M4.0 and smart factory initiatives.

There is also an expectation that data will play an important role in factory automation. Although only 15% of respondents include automation as a primary objective for their manufacturing data projects, they expect that number to more than double to 33% by 2030, signaling an expectation about automation’s growing and continued role in factories (Chart 10).

**BY 2030,
OPTIMIZATION,
PREDICTION AND
AUTOMATION WILL BE
PRIMARY OBJECTIVES**

What are your primary objectives for embarking on manufacturing data projects today? By 2030? (select top three)

- Today
- 2030

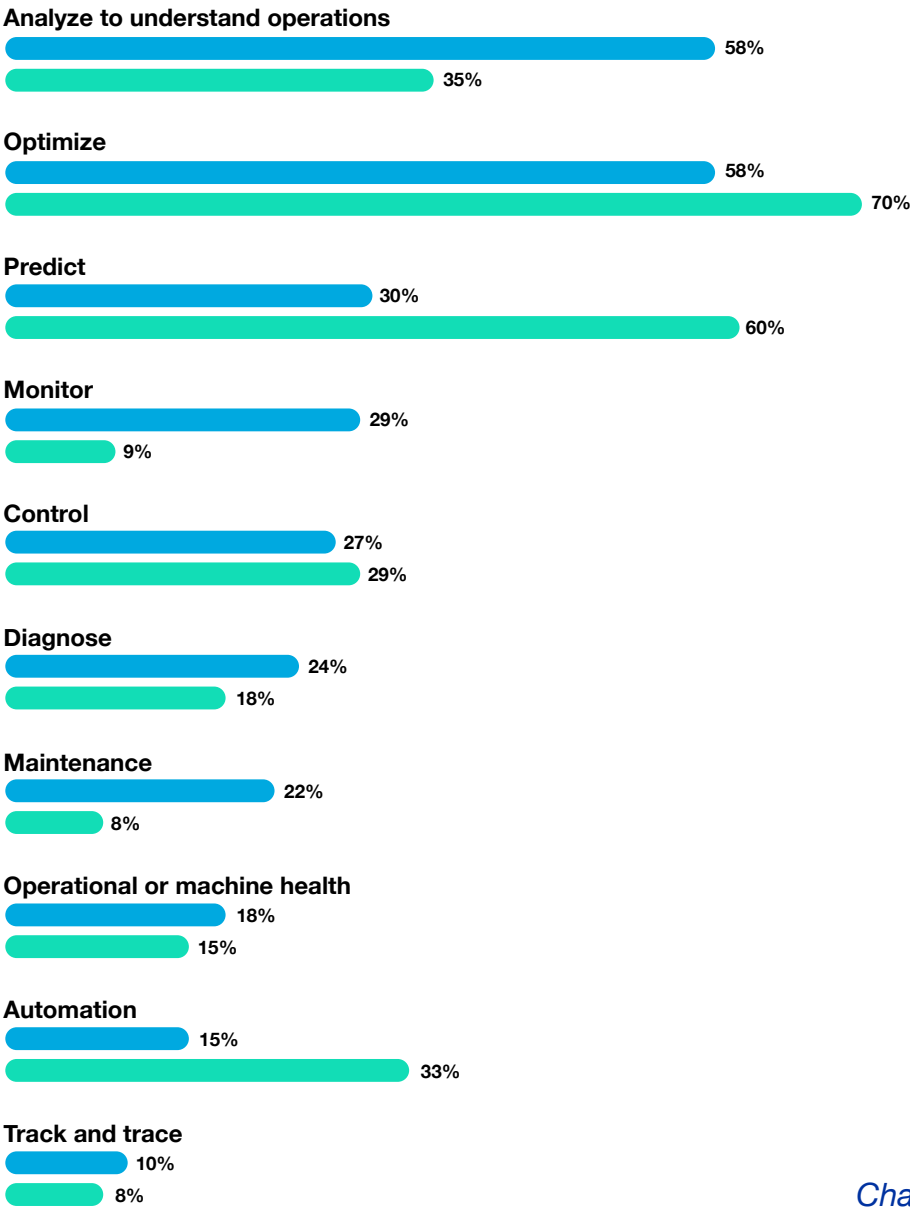


Chart 10

Digital transformation continues to evolve. With the continued spread of IIoT technologies, advanced sensors, more prevalent 5G networking and increased access to edge and cloud computing solutions, the data that manufacturers collect will increasingly be available in real-time. Right now, only a slight majority (56%) report that they are collecting at least half of their manufacturing data in real-time or near real-time (Chart 11).

PERCENTAGE OF REAL-TIME DATA USE VARIES

What proportion of the manufacturing data you collect today is real-time, or near real-time, not batch or historical? (select one)

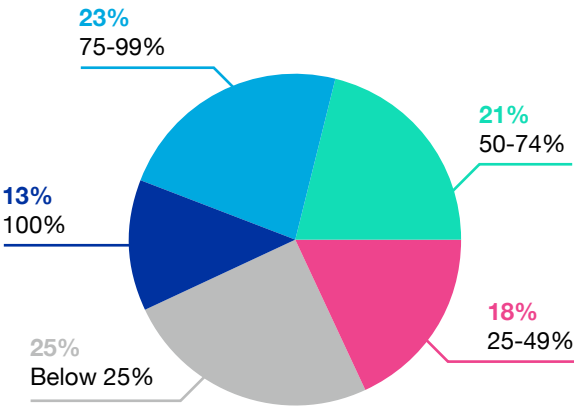


Chart 11

As real-time and near real-time data collection grows, the systems used to analyze and contextualize the data will likely shift. Currently, 68% of manufacturers report using spreadsheets to analyze at least some portion of their data. Meanwhile, 57% of respondents are using some form of artificial intelligence—an in-house AI system, cloud AI system or external analytics/AI partner—to analyze collected data. But as real-time data collection becomes more common, there will be a desire to make that data actionable in near real-time. This is one area where AI will excel beyond spreadsheets (Chart 12).

WHILE FORMAL ANALYTICS TOOLS ARE ON THE RISE, 68% OF MANUFACTURERS STILL USE SPREADSHEETS

What systems do you use to analyze the manufacturing data you collect? (select all that apply)

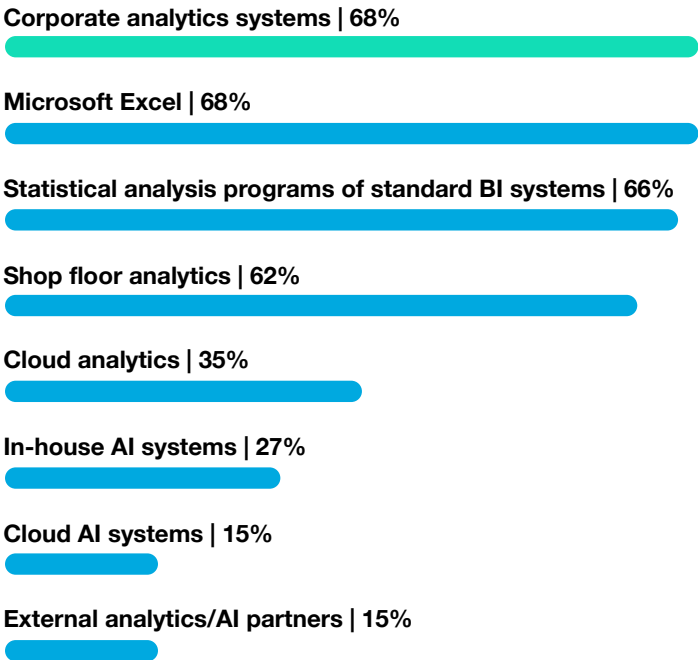


Chart 12

Another step toward real-time data collection and use is having standardized data formats. Current factories consist of a mix of legacy systems and new technologies. This dichotomy leads to non-standardized data. The survey numbers bear this out: only 46% of respondents say that at least half of their manufacturing data is standardized around clearly defined corporate standards or formats. By 2030, however, a whopping 87% anticipate that at least half of their data will be standardized (Chart 13).

BY 2030, STANDARD DATA FORMATS WILL PREVAIL

Considering the mix of new and legacy systems in most operations, what proportion of your manufacturing data is currently standardized around clearly defined corporate standards/formats at this time? By 2030? (select one)

- Today
- 2030

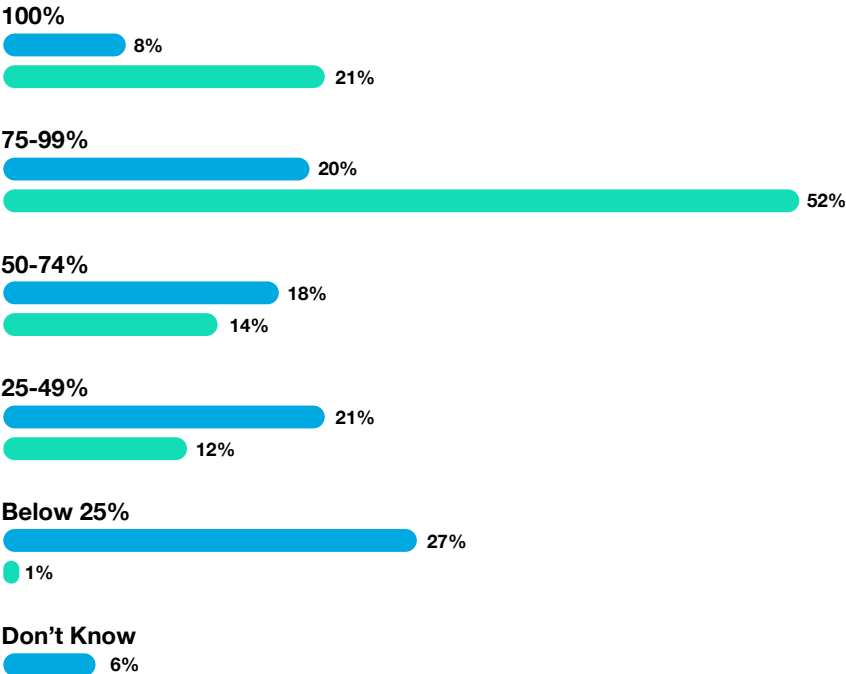


Chart 13



Given the positive change that better data collection, understanding, democratization, contextualization and use can have for an organization, it is not surprising that the data analysis work often falls on the continuous improvement team. At least, that is the case in 68% of respondents' factories. For others, factory supervisors (55%) and OT teams (52%) have primary responsibility for analyzing and generating insights from their manufacturing data. Only one-third of respondents report that operators are responsible for analyzing and generating insights from data (Chart 14).

**SITE LEADERSHIP
TEAMS HAVE PRIMARY
RESPONSIBILITY FOR
DATA INSIGHTS**

Organizationally, which
groups have primary
responsibility for
analyzing and generating
insights from your
manufacturing data?
(select all that apply)

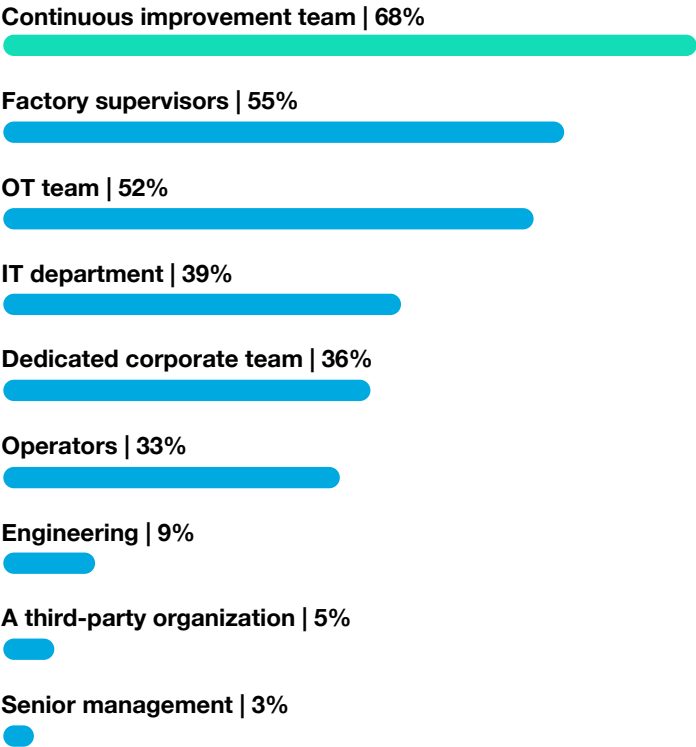
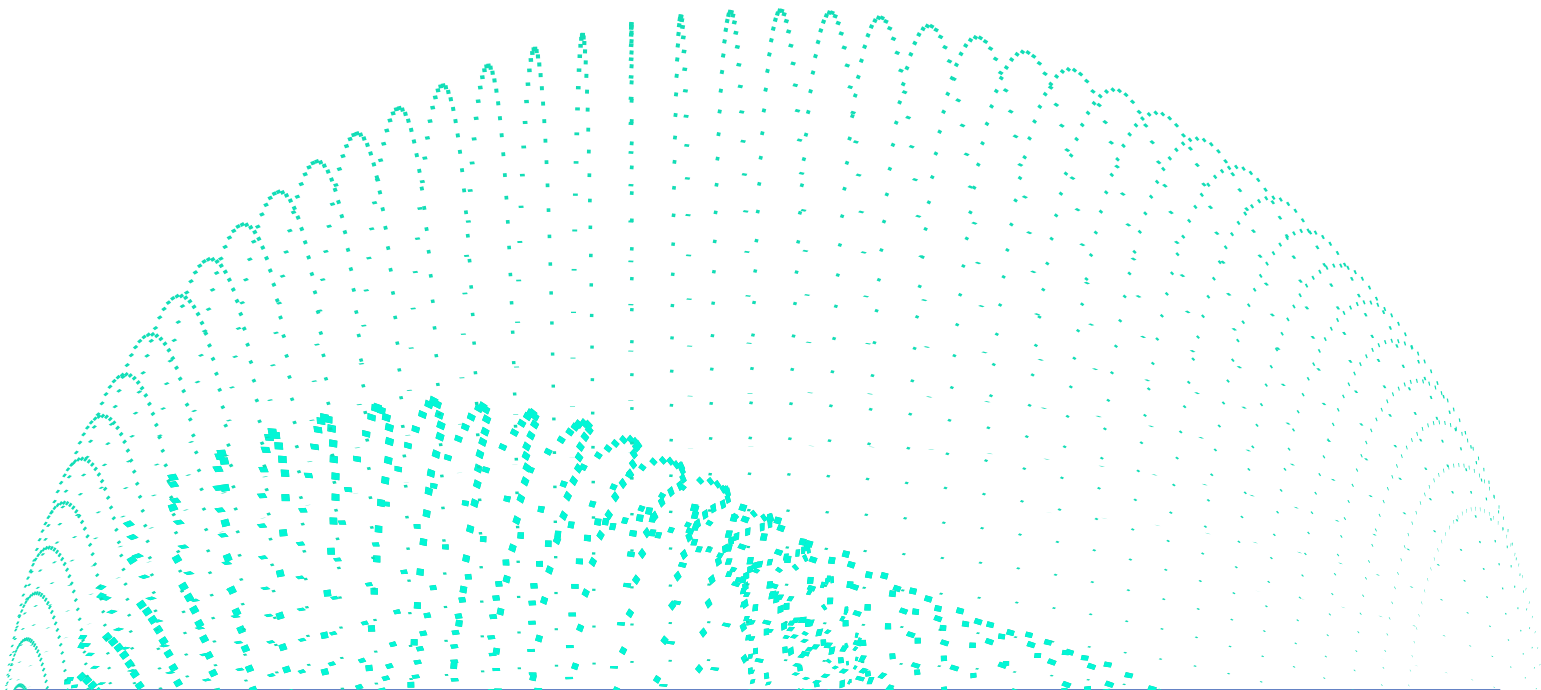


Chart 14



Meanwhile, when it comes to leveraging manufacturing data in the decision-making process, 77% of respondents report that the burden falls on plant leaders and managers. Others sharing this responsibility include factory floor supervisors and team leads (66%) and department and functional heads (63%). Like with data analysis, only one-third utilize factory floor employees to make decisions from data (Chart 15).

**RESPONSIBILITY FOR
DECISION-MAKING IS
DIFFUSED AMONG
LEADERSHIP RANKS**

Which roles are primarily
responsible for making
decisions based on
manufacturing data?
(select all that apply)

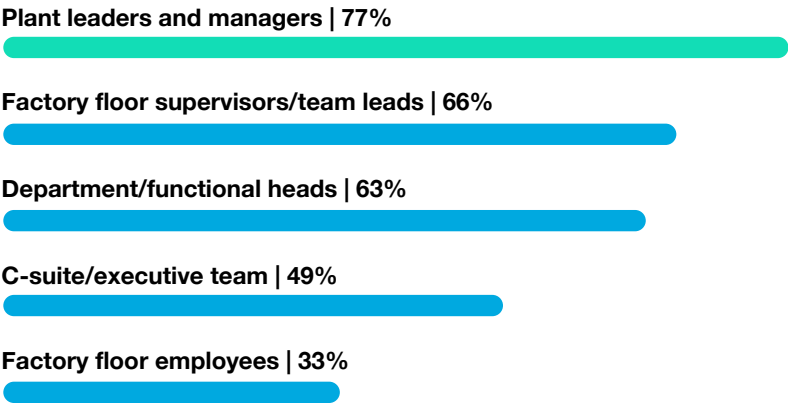


Chart 15

As we march toward 2030, M4.0 will continue to take hold, and the use of AI and other accessible digital technologies will become more established. Perhaps, operators and frontline workers’ roles will also evolve to include decision-making responsibilities for their tasks—leading to more real-time improvements, increased efficiency, and increased ROI.

The M4.0 journey is marked by a growing reliance on data as the driving force behind operational insights and strategic decision-making. The findings from MLC’s research underscore data’s pivotal role in shaping the future trajectory of manufacturing, highlighting both the opportunities and challenges that lie ahead. While advancements in technology promise a wealth of new possibilities, including real-time data collection, predictive analytics and automation, there remains a significant gap between available data sources and their optimal utilization. The prevalence of manual data entry, the disparity between traditional and emerging technologies and the ongoing struggle with standardized data formats all point toward a need for concerted efforts to harness manufacturing data’s full potential.

Looking toward 2030, manufacturing data is poised for significant transformation, with an increasing emphasis on proactive decision-making, predictive analytics and leveraging data for improved operational efficiencies. As M4.0 continues to evolve, the role of AI and other digital technologies will become more established, and perhaps reshape processes, roles and manufacturing itself.

SECTION 3

BUSINESS IMPACT

Most manufacturers leverage data to drive value across the organization through both bottom-line savings and top-line growth. However, measuring data's value is not the same as using data to recognize the value in M4.0 projects. Investments in how data is collected, organized, accessed and utilized need to be balanced with the value that is generated by that data through improved analytics, insights and decision-making. By treating data as an asset with financial (or other) value, companies can apply lean principles (e.g., minimize waste, drive efficiency, think of value streams) to ensure data is not being wasted.

Fewer than 50% of manufacturers are using some sort of validated financial metric (cost savings or direct revenue growth) to show the value of the data. Instead, companies are using second order metrics (specifically operational performance) as proxies for the data's value. Many manufacturers are already integrating their continuous improvement activities with their M4.0 digital transformation activities. Expanding this specifically around data projects is going to be the next important step as the industry builds toward 2030 (Chart 16).

THE MAJORITY OF MANUFACTURERS SEE BOTTOM-LINE METRICS AS THE PRIMARY MEASURES OF DATA VALUE

How do you measure the value of the data in your organization? (select all that apply)

Impact on operational performance | 61%



Cost savings in validated monetary terms | 47%



Direct revenue growth from new/improved products | 36%



Increased competitiveness | 30%



No measure for data value | 25%



Revenue of data-driven services | 12%



Increased net promoter score | 11%



Chart 16

Although they may not be using financial metrics for data, manufacturers do leverage lean principles to minimize waste and inefficiencies around data. They generally have confidence in their ability to collect (Chart 17) and analyze (Chart 18) the data they need from manufacturing operations. However, there is still significant opportunity—and need—for improvement: only about 25% have high confidence in either of these areas.

ONLY ONE-QUARTER OF MANUFACTURERS HAVE “HIGH” CONFIDENCE THE RIGHT DATA IS BEING COLLECTED

How would you rank your company’s ability to collect the right data the business needs from your manufacturing operations? (select one)

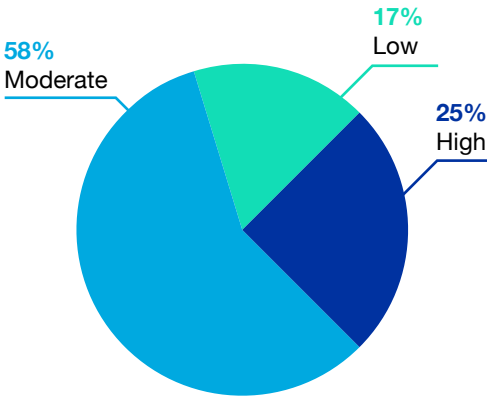


Chart 17

MOST MANUFACTURERS HAVE A “MODERATE” CONFIDENCE IN THEIR ANALYTIC CAPABILITIES

How would you rank your company’s ability to analyze the data from your from your manufacturing operations? (select one)

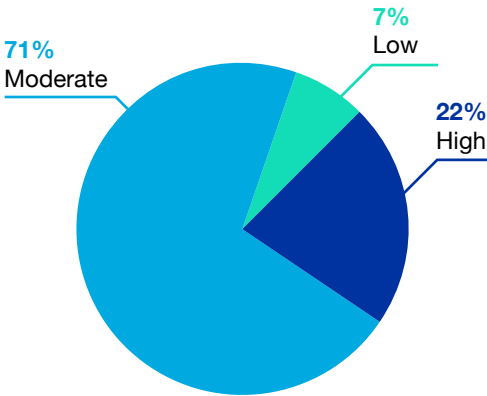


Chart 18

Given the confidence manufacturers have in their ability to collect and analyze the right data, it should not be surprising that increased manufacturing data has had a positive impact, specifically around operational metrics. The benefits are less impactful in areas beyond the factory floor. Competitiveness, innovation and workforce retention and attraction are all areas where more than 60% of respondents see little or no impact from increased manufacturing data.

Workforce development, in particular, where 24% of respondents see no impact flowing from increased data, is an area on which manufacturers should focus more. As more advanced technologies come into factories, the ability for organizations to leverage data to help workers develop skills and expertise will become more important. The payoff is that a more skilled workforce will lead to better efficiency with new M4.0 technologies and, in turn, create a more productive factory (Chart 19).

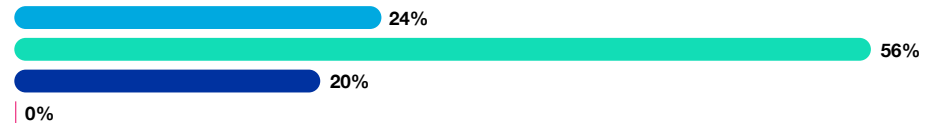


MANUFACTURING OPERATIONS ARE SEEING A POSITIVE IMPACT FROM THE INCREASE IN MANUFACTURING DATA

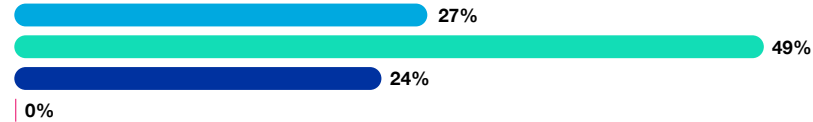
How has the increase in manufacturing data helped you to improve your manufacturing organization since 2020, or whenever you started your digital journey, to now? (whichever is earlier)

- High Impact
- Medium Impact
- Low Impact
- No Impact

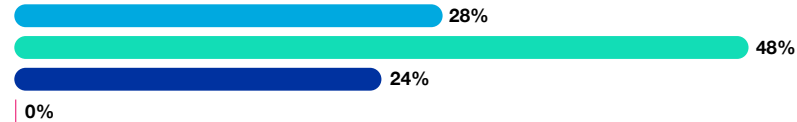
Cost reduction



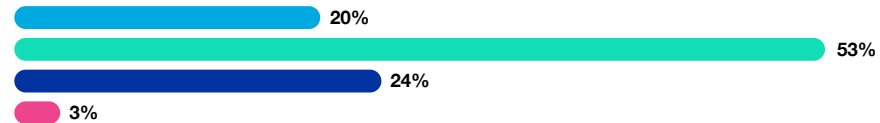
Efficiency



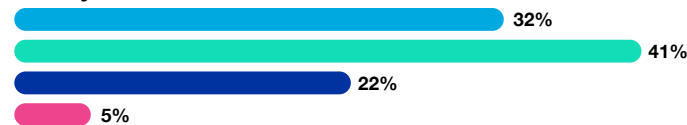
Productivity



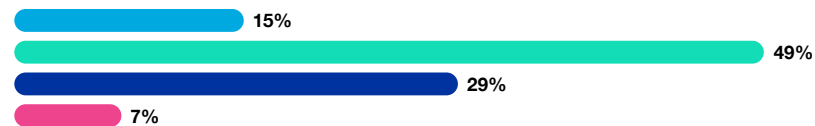
Speed



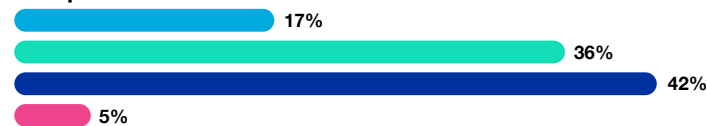
Quality



Process automation



Competitiveness



Innovation



Workforce retention/attraction



Chart 19

Decision-making can be converted into financial terms by focusing on the speed (turnaround-time) and quality (right versus wrong) of decisions. The ability to use data to drive decisions has had a very positive impact, with 95% saying decisions are faster, are of higher quality or both (Chart 20). Additionally, 65% of respondents frequently or constantly make data-driven decisions today with the expectation that nearly 95% will do so by 2030 (Chart 21).

DATA USAGE IS DRIVING IMPROVED DECISION-MAKING

How has the use of data affected your company's manufacturing decision-making? (select one)

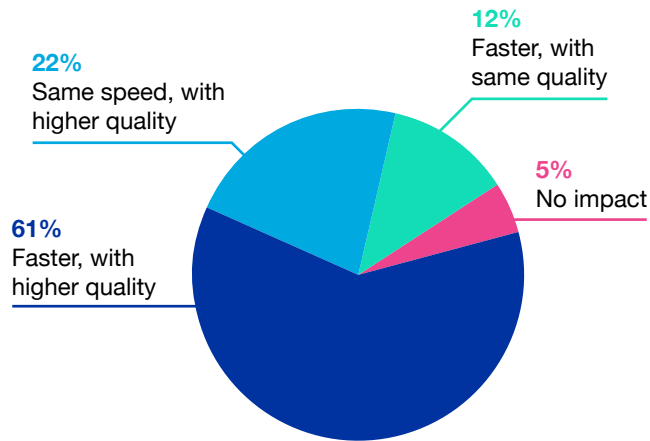


Chart 20

DATA-DRIVEN DECISION-MAKING WILL DOMINATE BY 2030

How often does your organization make data-driven decisions today? By 2030? (select one)

- Today
- 2030

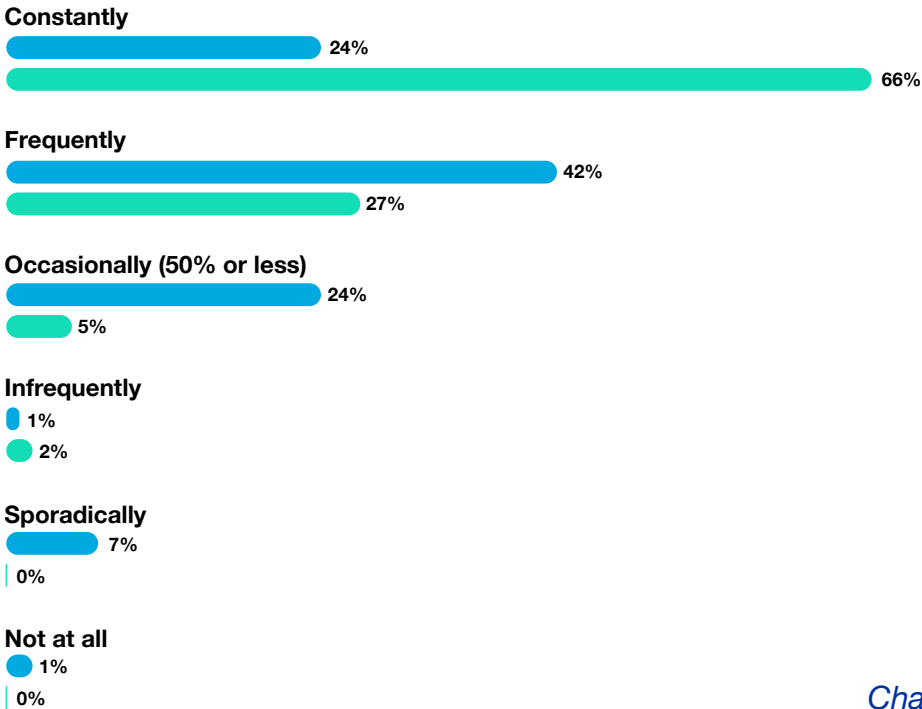


Chart 21

A key element the MLC is exploring is the expectation that digital threads, digital twins and data ecosystems will all be critical by 2030. To realize this future and data’s full value, companies need to focus on data integration. Only 41% of respondents say that data is shared across functions, indicating that silos still exist and will need to be broken down to reach the desired future state (Chart 22).

DATA SILOS STILL EXIST BOTH INTERNALLY AND EXTERNALLY

Is data routinely shared across any or all of the following parts of the organization? (select all that apply)

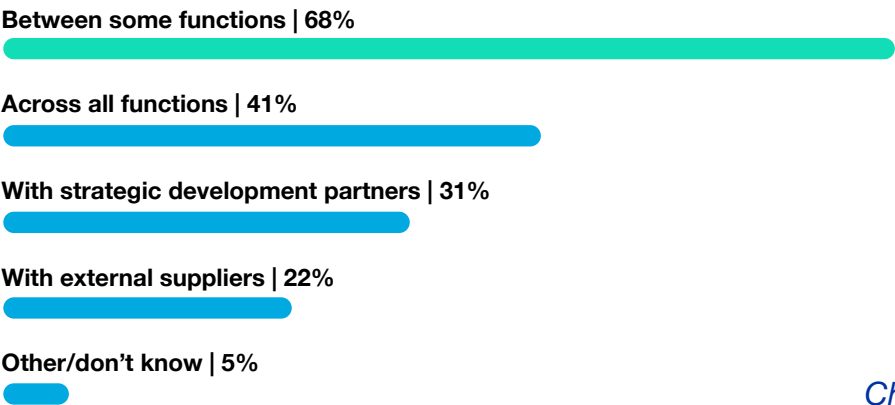


Chart 22



SECTION 4

FUTURE TRENDS

Data sharing across silos is of concern today. The survey shows that integration between systems is the number-one concern manufacturers see preventing them from achieving their goals. On the positive side, there is very little concern about the ROI of data-driven decision-making, so it is a matter of improved data governance, management and skills (Chart 23).

DATA INTEGRATION ACROSS SYSTEMS AND FORMATS IS THE TOP CHALLENGE

What are the most important challenges or obstacles hindering your organization from making more data-driven decisions? (select top three)

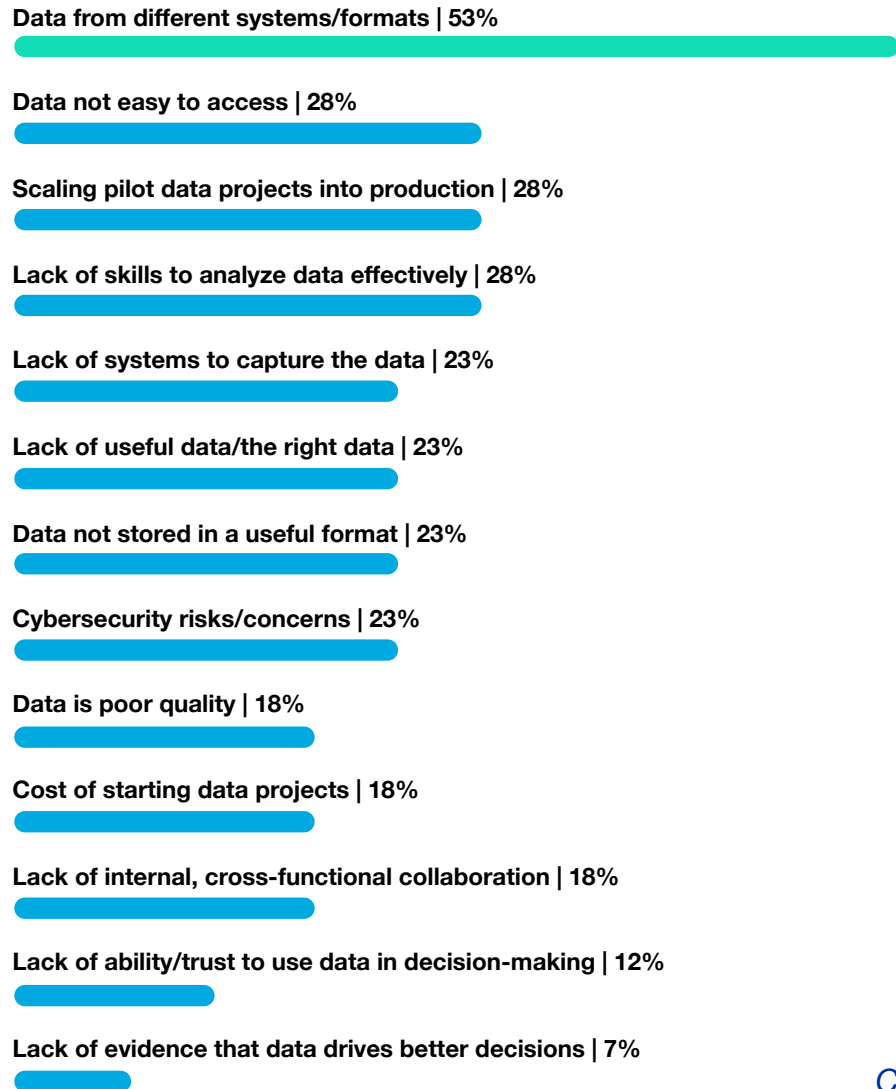


Chart 23

It is clear from all respondents that data will be a crucial aspect of future competitiveness by 2030. Taken by itself, this show of unanimity is a powerful statement about the future of manufacturing data. Looking closer at the numbers, there is an overwhelming majority (86%) who have said data will be essential—putting an exclamation point on this research and highlighting the need to improve data collection, standardization, analysis and usage (Chart 24).

**STRONG MAJORITY
SEES DATA AS AN
“ESSENTIAL”
ELEMENT OF
COMPETITIVENESS
BY 2030**

Looking forward to 2030, how important do you think manufacturing data will become to your competitiveness as a future business? (select one)

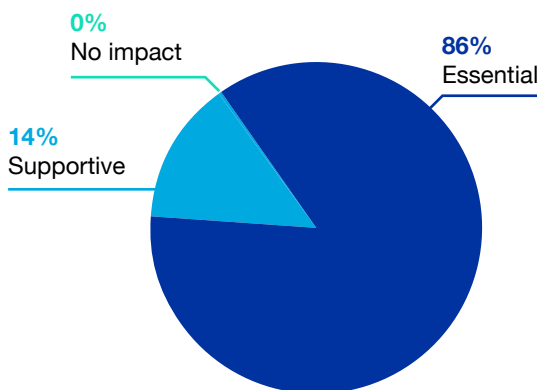


Chart 24



FINAL THOUGHTS

In its 2022 white paper, “The Next Phase of Digital Evolution,” the MLC characterized the opportunities and challenges around the use of operational data as a “Haystack Paradox.”

What was meant by this phrase was that growing volumes of data wouldn’t necessarily result in the revelation of meaningful insights that would benefit manufacturing companies—unless, that is, a number of other things happened to make those benefits come to life.

Chief among those other things—true then and true today—are organizing and analyzing data effectively, incorporating the results of trusted data analysis into decision-making processes and aligning business strategy closely with data strategy.

The results of the MLC’s new Data Mastery study show that the manufacturing industry is still in the grip of the Haystack Paradox and will most likely be so for some time. But it is not for a lack of trying. Manufacturers are making progress, but organizing well around the data opportunity is not a short-term exercise nor can it be static. Data volumes are growing too fast, and new technologies, such as generative AI tools, are coming to market too quickly for that to happen.

Seizing the data opportunity requires strategic thought, persistence and adaptability.

Manufacturing companies that achieve Data Mastery will know it when they do. They will innovate faster and more frequently, be more efficient and agile and become more competitive in their markets.

When that happens, all the hay will be woven into gold.



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Founded in 2008 and now a division of the National Association of Manufacturers, the Manufacturing Leadership Council's mission is to help manufacturing companies transition to the digital model of manufacturing by focusing on the technological, organizational and leadership dimensions of change. With more than 2,500 senior-level members from many of the world's leading manufacturing companies, the MLC focuses on the intersection of advanced digital technologies and the business, identifying growth and improvement opportunities in the operation, organization and leadership of manufacturing enterprises as they pursue their journeys to Manufacturing 4.0.

For more information, please visit
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The National Association of Manufacturers is the largest manufacturing association in the United States, representing small and large manufacturers in every industrial sector and in all 50 states. Manufacturing employs more than 12.7 million men and women, contributes \$2.71 trillion to the U.S. economy annually and accounts for 58% of private-sector research and development. The NAM is the powerful voice of the manufacturing community and the leading advocate for a policy agenda that helps manufacturers compete in the global economy and create jobs across the United States. For more information about the NAM or to follow us on Twitter and Facebook, please visit www.nam.org.

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