THE CONFERENCE BOARD

SUSTAINABILITY MATTERS

# Digitalization: an enabler for a circular economy

by Annika Hedberg and Stefan Šipka

Today, more and more businesses across different sectors are looking to pioneer digital solutions to create value, and to improve their processes, products and services. This transition is happening against the backdrop of a climate crisis and depletion of natural resources as well as an increasing global competition, which cast a shadow on businesses' prospects. Increasingly, companies are facing pressure to adjust and respond to these trends – and in these efforts, they could benefit greatly by building on the possibilities digitalization offers. This *Sustainability Matters* publication explores the role of data and digitally enabled solutions in accelerating the transition to a more sustainable, circular economy. That is defined as an economy that operates within the limits of this planet, and in which the resources are kept in use for as long as possible, products and materials are recovered and regenerated at the end of their service life.



SM-V3N1 | January 2020

## Background

Companies today are looking to embrace digitalization to develop new pathways for creating value. This increasing digitization and interconnectedness within value chains contributes to the fourth industrial revolution. Data is produced in several stages of the value chain by digital technologies such as sensors and connected devices, and digital solutions like digital platforms, artificial intelligence (AI) and blockchain are being used to improve processes, products and/or services. Digitalization can be an enabler for change, and a force for sustainability, if managed well. One of the greatest benefits of digitalization is its ability to address complexities.

There is currently no greater challenge than addressing the climate crisis and environmental challenges from resource depletion to pollution, which are affecting not only prospects for business but humanity. As companies are increasingly impacted by these trends, better management of data and digitally-enabled solutions can help them to adjust and be smarter with the existing resources, but also give them a competitive advantage in developing and deploying products and services that will be increasingly needed in the future.

> Circular economy broadly operates within the limits of this planet, and in which the resources are kept in use for as long as possible, and products and materials are recovered and regenerated at the end of their service life.

Considering the sustainability challenges but also increasing global competition, it is worth exploring the possibilities that digitalization offers in a transition to a sustainable, low-emission circular economy (CE). And the possibilities are manifold: better management of data and digitally enabled solutions can help to maintain the value of products and materials for longer; minimize resource use and waste; and increase repair, recovery/reuse of materials and products as well as recycling rates (Figure 1). Data and digitally-enabled solutions can help enhance connectivity and the sharing of information – a key barrier to a CE. They can make products, processes and services more circular. For example, companies can sell products as a service by using online platforms, which can reduce demand for new materials. Digital technologies can also encourage more sustainable consumption patterns. For example, using digital product passports – that provide detailed information on origins, material composition, guidance on reuse, repair and recycling etc. – could enable information exchange, which in turn can improve reuse and recovery.

Figure 1
**Digital Circular Economy**


Source: European Policy Centre, 2019

However, digitalization is not a silver bullet to greater sustainability. In fact, there is a risk that if it is not guided well, it can result in unwanted rebound effects, such as an overdrive of a linear 'take-make-dispose' economy and increase in greenhouse gas (GHG) emissions. Thus, it is extremely important to ensure that digitalization efforts are geared towards achieving the United Nation's Sustainable Development Goals (SDGs) and Paris Agreement, including addressing climate change and environmental challenges, while used as tools for enhancing competitiveness and industrial modernization.

> Digital technologies can help minimize consumption and waste while maximizing utilization and value in a variety of ways.

## Digitalization enables circular economy by improving connections and information sharing

The digital revolution implies that more digital data is being generated than ever before. Numerous digitally enabled solutions (e.g. digital sensors, mobile phones, connected devices, satellites) are used to generate and collect new data, including for specific purposes such as for accelerating a CE. For this data to be turned into information and gain value, it must be managed – that is, mined, systematized, processed and shared.

Figure 2
**Improve Connection and Information Sharing**


Source: The Conference Board, 2020

A transition to a CE could benefit greatly from collection and exchange of information, converting data to information and actionable knowledge, improved connections between relevant stakeholders across the value chain, and solving issues around information sharing (Figure 2). Especially the latter is currently a major hurdle to achieving a CE and finding a way to share information while respecting companies' intellectual property rights (IPRs) could provide a breakthrough in creating a CE. The examples have been selected to demonstrate the scope of the different possibilities.

Table 1 **Improve Connections and Information Sharing**

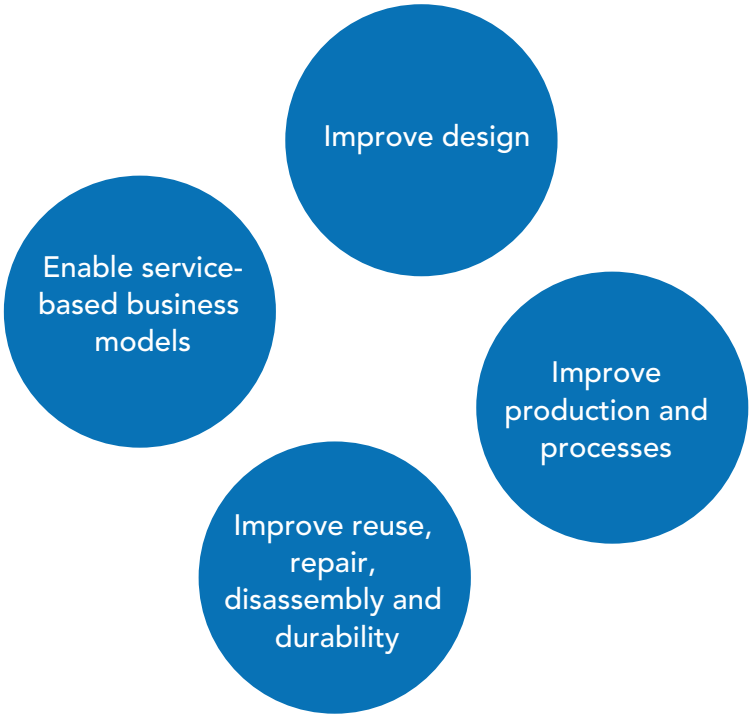
| Measure | Description | Example(s) Existing Solution | Example(s) Emerging Solution |
|---|---|---|---|
| Information collection and exchange | Databases and platforms can allow information exchange for the benefit of CE . | The European Resource Efficiency Knowledge Centre platform provides information to businesses, about improving resource efficiency. Several industries have created databases to record substances used by the industry, manage their supply chains and comply with EU requirements (e.g. BOMCheck and International Material Data System (IMDS) for automotive companies). | The recently amended Waste Framework Directive stipulates that the ECHA should develop a database on hazardous substances in products and materials. It is envisaged to be used primarily by consumers for information and waste operators to improve waste treatment. |
| Improve information | Data collection and management can be used to create insights for the benefit of a CE. | Evolution3 is an advanced sensor system for tires developed by Michelin: tires communicate their temperature and pressure conditions in real-time via e.g. email and text messaging. Thus, the data is turned into actionable knowledge that can be used to prevent overheating, a major cause of tire damage. | Comprehensive life-cycle assessments (LCAs) can be an important information tool for more sophisticated decision-making while improving data management can help to make LCAs more efficient and accurate. Software like openLCA, GaBi and SimaPro are already used in industries and academia to execute LCAs, and digitally-enabled LCAs surely carry potential to support also policymaking. |
| Facilitate partnerships | Digitalization can help partnerships and collaboration between stakeholders – including business-to-business (B2B) and business-to-consumer (B2C). E.g. online platforms enable buyers, sellers, and citizens to connect and exchange information, good practices and resources, also across borders. | The European database Urban Mine Platform shows valuable materials made available from high tech products through "urban mining," to improve the recovery and value retention of secondary raw materials. | BE CIRCLE is a web-based platform supporting industrial symbiosis. The software enables users to visualize nearby industrial facilities and their materials, and water and energy stocks and flows, giving potential synergies. |
| Enable information to travel across the value chain | Consumers would benefit from having the necessary information on how to maintain, repair and recycle a product. The reuse of materials and products could be encouraged if there was better information about their quality and lifetime maintenance. Recycling could be improved if waste operators had the necessary knowledge on used materials or substances. | The French group Auchan uses RFID technology to track crates for reverse logistics. It recently announced that it would introduce blockchain technology to its operations, following successful local testing. | The Dutch Circularise uses blockchain to improve transparency and communication across circular value chains. Its Smart Questioning technology enables stakeholders a Q&A on a product via secure communication. It allows for more efficient data sharing while also addressing the industry's need for data protection. |

## Embedding digital when making products, processes and services more circular

A transition to a CE will require making products, processes and services more sustainable. This requires changes to how we design, produce, use, reuse, repair and recycle products. This implies improving industrial processes. It will require new circular business models. Digitalization can make a significant contribution to all these components of CE; it is already affecting how businesses operate, and the solutions they provide.

The examples below aim to give a taste of some of these possibilities. It is also worth noting that there are some sectors, including construction, plastics, textiles, electronics, food systems and automotive, where a (digital) transition to a (digital) CE could be greatly beneficial, even in the short term.

Figure 3
**Making Products, Processes and Services Circular**




Source: The Conference Board, 2020

Business models are increasingly shifting from producing goods to delivering services, and digitalization (e.g. digital platforms) plays a major role in this development. Think selling light instead of light bulbs, mobility instead of cars, music instead of CDs. Some textile producers are offering rental and recycling services for their clothes. Instead of buying home appliances, consumers can rent them. These practices encourage product longevity and reusability, and even dematerialization, which in turn can reduce demand for materials and negative externalities like waste and emissions.

Table 2 **Making Products, Processes and Services Circular**

| Measure | Description | Example(s) Existing Solution | Example(s)Emerging Solution |
|---|---|---|---|
| Improve design | Designing products and materials that are more sustainable, durable, reusable and easily disassembled, upgraded and/or recycled is central to creating a CE. Much work remains to be done, but innovative approaches like using AI in design processes are promising.[a] AI can be used to improve the processes, as it allows designers to play with numerous materials and structures and test and refine design suggestions. | *No appropriate examples* | The Accelerated Metallurgy project funded under H2020 aims to identify environmentally friendly metal alloys and create new materials via AI. |
| Improve production and processes | The production of materials, components and final products can be energy- and resource-intensive and lead to significant amounts of waste. Digital tools can optimize processes by preventing waste and emissions and reducing energy and resource consumption. They can be used to facilitate industrial symbiosis and exchange of materials between businesses. New technologies like 3D printing can also boost the development of local solutions by helping local manufacturers produce and deliver products and services to customers on-demand. | GreenLab Skive is an industrial park developed as a public-private partnership in Danish Skive Municipality. Park members rely on the integrated intelligent infrastructure that enables energy exchanges between businesses and optimizes its usage. | Companies such as Bosch and Siemens are developing and rolling out smart digital factories, built on AI and machine learning, which can reduce energy consumption and waste during production. 3D printing can optimize production and increase environmental performance by using only the exact amount of material needed. |
| Improve reuse, repair, disassembly and durability of products | Extending the lifecycles of products like electronic appliances through repair, remanufacturing and reuse is central to a CE, and several new and emerging digitally enabled solutions already contribute to these efforts. Online platforms can be used as a source of information and to connect stakeholders. Data exchange could enable the identification and safe recovery of equipment that can be remanufactured; and avoid it from being recycled, dismantled or repurposed for a lower value function. Durability can be enhanced, and repair facilitated via connected machines that provide real-time information on the condition, state and availability of products. When data is used to identify problems with the functioning of products, thus contributing to predictive maintenance, cheaper and more efficient reparations become possible. | iFixit is an open-source online platform for repairing electronics, machinery and car components mostly. It contains repair guides, Q&A forums and user-generated updates on existing and prospective equipment. Its challenge is that it does not provide any guarantee on the reliability of the information posted. | Connected machines can be used to conduct predictive maintenance – a machine can inform the maintenance staff about potential problems via IoT. German thyssenkrupp gathers elevator data and uses IoT to enable predictive maintenance. |
| Enable service-based models | Business models are increasingly shifting from producing goods to delivering services, and digitalization plays a major role in this development. An example of a service-based business model that has a strong circular component is 'products as a service', where consumers purchase a desired result rather than just equipment. In its simplest form, existing products can be combined with value-added services. Products can also be owned by suppliers; customers pay for their usage while suppliers monitor product performance and take timely, predictive maintenance measures, for example. | | "Clothing as a service" online platforms are growing in Europe and beyond. Tale Me is a Belgian rental service for maternity and children's clothes. The Dutch brand MUD Jeans rents and recycles denim clothing.<br>Other service-based examples include Phillips Lights 'light as a service' and HP Insta Ink, both of which are made possible through connected machines. |

[a] See e.g. "Artificial Intelligence and the circular economy", Ellen MacArthur Foundation (2019).

## Barriers, challenges and risks to be addressed

Digitalization can help to tackle barriers and accelerate a transition to a CE. However, there are fundamental barriers to both transitions that will need to be kept in mind.

### Basic barriers to achieving circular economy

Fundamental challenges to a CE which demand attention, with or without digital support, are:

- the existing economic model does not value natural capital, nor internalize externalities of measures taken (e.g. price negative and reward positive social and environmental impacts);
- the lack of incentives for companies to design more circular products and use secondary raw materials;
- products, materials and substances on the market contain banned substances of concern, either because they were introduced before being banned or due to the lack of enforcement (e.g. REACH[a]);
- information does not travel with products and materials, hampering circular practices like maintenance, reuse, repair and recycling;
- the overload or lack of information on products, complicating consumers' ability to make sustainable choices;
- the insufficient quality criteria for secondary materials and lack of demand for recycled materials, like plastics;
- the lack of common definitions for waste, and hazardous waste hinder shipments of waste across member states;
- illegal waste burning or shipments, different levels of ambition across the EU in reducing landfills and meeting the agreed recycling targets, and the overall underdeveloped waste management infrastructure;
- the global market and value chains complicate policy steering at the EU level.

### Basic barriers to achieve digital economy

Better data management and use of digitally enabled solutions for a CE are not always straightforward. Many of the basic challenges are the same as for the digital transition in general:

- Inadequate digital infrastructure for connectivity, Internet coverage (i.e. high-speed broadband, 5G, fibre) and cybersecurity;
- Data is not always standardized, comparable nor digital. Different data formats or low-quality data lead to poor outputs. The lack of clarity on data ownership, degrees of freedom on data flow, and the continuous search for a balance between information sharing and protection of citizens' and businesses' sensitive data impact data economy developments, too;
- The private and public sectors', and citizens' concerns on the privacy, security and trust related to the use of data can limit access and its usage;
- The lack of interoperability between systems and data can impair data flows and analysis; Difficulties to update old hardware with new software spurs faster turnover of hardware;
- Slow development and deployment of emerging technologies like AI and Internet of Things (IoT) due to a lack of investments, innovation and digital skills;
- The lack of basic digital skills and e-literacy in over a third of Europeans in the active labor force. Furthermore, the lack of information technology (IT) and AI professionals is a hindrance to the digital transition;
- The barriers to digital services such as geo-blocking, procurement rules (i.e. favoring products over services) and the difference in fees for services and products. Donations (e.g. unused or reusable products from e-commerce) are discouraged when charged with additional value-added tax (VAT).

[a] REACH is a European Union regulation concerning the Registration, Evaluation, Authorization and restriction of Chemicals

## Managing the unintended contradictions and consequences

There are several other risks and potential contradictions that must be acknowledged and addressed in the process in order to avoid unwanted consequences.

While a greater circularity can help achieve a more sustainable, competitive and climate-neutral economy, the measures taken do not automatically help to reduce emissions or change production and consumption patterns. Recycling is a good example: increasing it alone does not ensure the quality of recycled materials or demand for secondary raw materials. Product features like greater durability or recyclability do not automatically lead to lower energy use or emissions. For example, shifting away from single-use plastics may lead to higher usage of energy-intensive materials such as metal or glass.[1]

On a similar note, greater use of data and digital solutions do not automatically contribute to reducing GHG emissions and smarter use of resources or lead to more sustainable production and consumption. In fact, digitalization can very likely cause the opposite if not guided and governed well. Digital services, such as e-commerce, can contribute to increasing (unsustainable) consumption. Products imported from outside the EU carry the risk of containing materials and substances that are not permitted in the EU and will be difficult to reuse and/or recycle.

Moreover, the information and communications technology (ICT) sector has a significant environmental footprint. Data centers, digital devices and digital infrastructures require significant levels of energy and materials. ICT accounts for 5 to 9 percent of the total electricity demand (associated with GHG emissions) with a potential increase to 20 percent by 2030, as the demand for data centers, cloud computing and other energy-intensive technologies (e.g. blockchain) increases. Considering the amount of energy digitalization requires, these developments must be coupled with a transition in our energy system (e.g. increasing energy efficiency and share of renewables).

Simultaneously, resource use and waste are a problem. The world produces annually 50 million tons of electronic waste or e-waste, and the amount is increasing due to rapid technical development. This is a missed economic opportunity, as enormous amounts of valuable, critical materials are thrown away. Landfilling and informal recycling of e-waste also have unwanted health and pollution impacts. Overall, organizations need to consider and adopt responsible business practices vis-a-vis digitalization.[2]

1 BBC (2018), "Total Ban on plastics 'could damage environment'".

2 Responsible Digital: Extending Ethical Business Principles to Digitalization, The Conference Board, 2019.

## The EU framework for action

Major efforts are currently being taken by the European Union (EU) and national policymakers to promote transitions to i) a sustainable, circular economy and ii) a digital economy. These ambitions are well reflected in the European Commission's call for a 'European Green Deal' and 'A Europe fit for the digital age'. However, so far these transitions have been pursued separately from another.

The EU Action Plan for the Circular Economy, also known as the Circular Economy Package, adopted by the Juncker Commission in 2015, provides an outline of policy and legislative measures for improving production, consumption, waste management, markets for secondary raw materials, innovation, investments and monitoring. It has led to new legislation (e.g. Single-Use Plastics Directive) and amendments into existing ones (e.g. the Waste Framework Directive). However, the work has only started and the new Commission will propose an updated Circular Economy strategy. It is essential that it contributes to reducing the EU's emissions, resource dependency and waste; improving reuse, remanufacturing and recycling; keeping valuable materials in Europe; and recognizing the linkages with digitalization.

As **product design** is a key to a CE, companies must be incentivized to design with circularity in mind. Sharing best practices and encouraging the use of digital solutions like AI would be important. While the Ecodesign has been an effective instrument in making products more energy efficient, the Commission should explore whether the *Ecodesign Directive* and product design guidelines could be better aligned with a (digital) transition to a (digital) CE. While considering requirements for new product categories to enable the greater durability, reparability and recyclability of products, the possibility of integrating digital tools into products to support information sharing could also be investigated.

**Extended producer responsibility** (EPR) is a policy approach that assigns producers responsibility for their products, even past the consumption stage. While the focus has primarily been on the end-of-life phase (e.g. producers covering waste management costs), EPR can also be used to incentivize producers to design more sustainable products.[3] Possibilities to use data and digitally-enabled solutions to improve the functioning of the EPR (e.g. by enabling more efficient information sharing between producers and recyclers) should be further explored.

**EU ecolabel** can help highlight a product's environmental footprint to consumers, while digitally enabled solutions like QR codes, apps or online platforms can be used to clarify and communicate the information within the label to answer consumers' questions and help them make sustainable choices.

The Commission has proposed spending 15 percent of the **EU budget** in 2021-27 on the single market, innovation and digitalization. As more detailed discussions continue e.g. on the projects under the **Horizon Europe** (research & innovation) and the **Digital Europe** funding programs, more should be done to incentivize and support development and deployment of digitally enabled solutions for a sustainable CE.

As finding ways to ensure efficient and secure information sharing while respecting companies' intellectual property rights (IPRs) across value chains could provide a breakthrough for creating a CE, the EU should investigate incentivizing and enabling fair **access to and sharing of data/information**. It should start developing guidelines for tracking products, materials and substances across the value chains. At the same time, it should explore the possibilities that solutions like **blockchain** and distributed ledgers could offer.

3 *Organisation for Economic Co-operation and Development*, "Environment Directorate > Environmental policy tools and evaluation > Extended producer responsibility" (last accessed 25 June 2019).

## Insight's for what's ahead

Improved use of data and the ongoing development and uptake of digital solutions are fundamentally reshaping our economy and society. Digitalization offers great possibilities also for companies to improve their own business models and advance industrial symbiosis and collaboration with partners in the value chain. It is in the companies' interest to future-proof their processes, products and services by responding to the ongoing sustainability challenges as well as the commitments made under SDGs and the Paris Agreement[4].

While the approach and specifics may vary by industry and region, the principles for companies to embrace CE are consistent.

- Think systematically and bring together different functions (e.g. sustainability, innovation, digital, product design and development) to ensure data and digital solutions are used to accelerate a transition to sustainable and circular processes, products and services. Adopting a culture of experimentation and adaptability along with moving at speed can help catalyze initiatives.
- Form coalitions of the willing and find partners that want to build on the first-mover advantage and work together across the value chain in developing partnerships. The aim should be to improve collaboration between manufacturers and recyclers to ensure that products can be dissembled, and materials recycled and find ways to share the created value.
- Start by improving information transfer in sectors/amid businesses that operate in closed supply chains. They should use digital technologies to track and trace materials and substances and include information that is relevant for the users down the value chain e.g. with the help of QR codes and watermarks.
- Utilize existing EU platforms to exchange on digitally enabled solutions for circular economy, with an aim of becoming standard-setters for such products and services that will be increasingly in demand also globally. Use the platforms to exchange good practices also on information transfer.
- When possible, use shortcuts when improving data/information sharing in the value chain: e.g. the Circular Content Management System (textiles), BOMCheck (chemicals) and International Material Data System (vehicles) could be replicated also in other sectors. Also existing initiatives for developing a data sharing economy, e.g. by International Data Spaces Association, can provide a valuable basis for further reflection.

4 The Paris Agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C.

- Develop a systematic approach towards improving workers' digital literacy and digital skills. Workers need to become more accustomed to using solutions such as the IoT, 3D printing, AI and blockchain, and contributing to data sharing with waste managers and consumers.
- Prepare for the implications of the EU regulation on conflict minerals (coming into force in 2021) that will impact the availability of tungsten, tantalum, tin and gold, and thus future production of digital products.
- Pro-actively contribute to developing a structure and principles for information sharing that can respond to the different challenges and needs across the value chains, and that can contribute to related developments at the EU and global levels.
- Follow closely developments on the EU Green Deal, circular and digital agendas as well as on industrial strategy and innovation policy. Provide policymakers with case studies that demonstrate the benefits of aligning the agendas but also recommendations for needed framework conditions for further action.

This Sustainability Matters publication is based on 'Creating a digital roadmap for a circular economy' report that summarizes some of the key findings of the EPC's 2-year long project on the topic, written by Annika Hedberg and Stefan Šipka with Johan Bjerkem.

## Other related reports

### Trash Woes: Unpacking China's Waste Plastics Ban—Implications for Business

For many years, China was the main final recipient of the global flow of plastics waste—millions of tons were shipped to China every year. In 2017, with the implementation of severe import restrictions, China effectively shut its doors on foreign waste plastics. The result? Seemingly overnight, China's share in global waste plastics imports plummeted, leaving much of the developed world sitting on mountains of plastics trash. Two years on: How are global plastics waste streams changing? How is the ban affecting the economics of plastic collection and recycling? What were the real reasons behind the ban, and what is happening now within China? This report provides answers to these questions and assesses short- and long-term implications for business.

### EU Circular Economy Package: A Challenging Yet Important Impulse

Corporate boards need to understand the impact of the EU Circular Economy Package for the following reasons: anticipation of regulation, stakeholder pressures, business model disruption, risk management, and shareholder responsibility. This report evaluates the EU Circular Economy Package by providing facts on the status quo of circular economy efforts and outlines some of the risks and opportunities for companies.

### Business Transformation and the Circular Economy

Natural resource constraints and global environmental risks are challenging the traditional linear economy – where companies "take, make, dispose". Companies are facing pressure to adjust to a new circular economy – one in which resources are kept in use for as long as possible, and products and materials are recovered and regenerated at the end of their service life. This report examines how companies can successfully transform their business models and capture value and minimize risk in a circular economy.

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The European Policy Centre is an independent, not-for-profit think tank dedicated to fostering European integration through analysis and debate, supporting and challenging European decision-makers at all levels to make informed decisions based on sound evidence and analysis, and providing a platform for engaging partners, stakeholders and citizens in EU policymaking and in the debate about the future of Europe.

## ACKNOWLEDGEMENTS

The authors would like to thank Anuj Saush, senior researcher at The Conference Board for his tremendous contribution to developing this report and help connecting the ideas of Creating a Digital Roadmap for a Circular Economy report to the wider market. The authors would also like to thank Gary Larkin, a former research associate at The Conference Board.

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