Bernardo Nicoletti

Procurement 4.0 and the Fourth Industrial Revolution

The Opportunities and Challenges of a Digital World

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Bernardo Nicoletti
Temple University Rome Campus
Rome, Italy

Università di Tor Vergata
Rome, Italy

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Abbreviations

ABI	Associazione Bancaria Italiana
AGV	Automated Guided Vehicle
AMA	American Marketing Association
API	Application Programming Interface(s)
ASC	Agile Supply Chain
B2B	Business to Business
B2C	Business to Consumer
BAS	Building Automation Systems
BAU	Business as Usual
BCG	Boston Consulting Group
BDAQ	Big Data Analytics Quality
BOL	Bill of Lading
BOM	Bill of Materials
BPaaS	Business Process as a Service
BPO	Business Process Outsourcing or Business Process Optimization
CAGR	Compounded Annual Growth Rate
Capex	Capital Expenditure
CBR	Case-Based Reasoning
CFFR	Collaborative Planning, Forecasting, and Replenishment
CFM	Cash Flow Management
CLM	Contract Lifecycle Management
CNC	Computer Numerical Control
COPIS	Customer, Output, Process, Input, Supplier
CPM	Critical Path Method
CPM	Corporate Performance Management or Critical Path Method
CPO	Chief Procurement Officer
CPS	Cyber-Physical System

CRM	Customer Relationship Management
CWL	Carlson Wagonlit Travel
DBA	Database Administration
DDLC	Document Development Lifecycle
DTC	Digital Trade Chain
E-Proc	e-Procurement
ECM	Enterprise Content Management
EDI	Electronic Data Interchange
EERP	Extended Enterprise Resource System
EMS	Small and Medium Enterprises
EOQ	Economic Order Quantity
EPC	Engineering, Procurement, and Construction
ERP	Enterprise Resource Planning
EVI	Early Partner Involvement
FMCG	Fast-Moving Consumer Goods
FTE	Full-Time Equivalent
GDPR	General Data Protection Regulation
GIS	Global Information Systems
GMS	Global Mobile System
GPO	Group-Purchasing Organization
GPP	Green Public Procurement
GRI	Global Reporting Institute
IaaS	Infrastructure as a Service
IBIN	Intelligent Bin
ICC	International Chamber of Commerce
ICT	Information and Communication Technology
IoE	Internet of Everything
IoO	Internet of Objects
IoP	Internet of People
IoS	Internet of Services
IoT	Internet of Things
ISO	International Standard Organization
ITS	Integrated Transport Management System
JiT	Just in Time
KPI	Key Performance (or Process) Indicator
KPO	Knowledge Process Outsourcing
KRI	Key Risk Indicator
KYC	Know Your Customer
LAN	Local Area Network
LGV	Laser Guided Vehicle
LMS	Logistics Manufacturing Services
MaaS	Mobility as a Service

MDM	Mobile Device Management
MMR	Mass Market Retailers
MMS	Managed Mobility Services
MMSP	Managed Mobility Services Provider
MOU	Memorandum of Understanding
MRO	Maintenance, Repair, Operations (Material)
MRP	Manufacturing and Material Requirement Planning
MSA	Master Service Agreement
MTO	Make to Order
MTS	Make to Stock
MWM	Mobile Workforce Management
NFC	Near Field Communication
NIST	National Institute of Standards and Technology
OBS	Organization Breakdown Structure
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
OMP	Open Manufacturing Platform
Opex	Operating Expenditures
OT	Operations Technology
P2P	Purchase to Pay
PaaS	Platform as a Service
PBI	Process Business Intelligence
PLC	Programmable Logic Controller
PLM	Product Lifecycle Management
PROU	Perceived Ease of Use
R2P	Requisition to Pay
RACI	Responsibility-Accounting-Control-Information
RFB	Request for Bid
RFI	Request for Information
RFID	Radio-Frequency Identification
RFP	Request for Proposal
RFQ	Request for Quotation
RFX	Any Type of Request for Procurement
ROA	Return on Assets
ROI	Return on Investment
RPA	Robot Process Automation
RTLS	Real-time Locating System
S2P	Source to Pay
SaaS	Software as a Service
SCF	Supply Chain Finance
SCM	Supply Chain Management
SIM	Subscriber Identity Module

SIPOC	Partner, Input, Process, Output, Customer
SKU	Stock-Keeping Unit
SLA	Service Level Agreement
SMS	Short Message Service
SRM	Supplier Relationships Management
STP	Straight Through Processing
SWOT	Strengths-Weaknesses-Opportunities-Threats
TAM	Technology Acceptance Model
TCM	Total Cost Management
TCO	Total Cost of Ownership
TIM	Trust in Motion
TMS	Transportation Management System
TQM	Total Quality Management
UAV	Unmanned Aerial Vehicles
UMTS	Universal Mobile Telecommunications System
VA/NVA	Value-Added/Non-Value-Added
VoC	Voice of the Customer
WAN	Wide-Area Network
WBS	Work Breakdown Structure
WIP	Work in Process
WMS	Warehouse Management System
WSN	Wireless Sensor Networks
XML	Extended Messaging Language

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CHAPTER 1

Introduction

The global recession has hit hard in many areas and all major functions of organizations have been impacted. Figure 1.1 summarizes some of the challenges organizations face in light of this situation. The importance of developing and managing innovative strategies in the field of procurement is clear. From a historical perspective, procurement has undergone huge transitions, especially in the last decades, in the sense that organizations have had to deal with pressures relating to cutting costs and increasing profits.[1]

It is essential to innovate through process improvement and automation management. To analyze how this can be done, a possible entry point is to scrutinize the implementation of innovations. This book presents such a new approach, calling it 'procurement 4.0.' This approach represents a set of solutions that can support managers and buyers at all stages of the procurement process, from strategic procurement to pre-negotiation (the search for new partners), up to the monitoring of expenditure and giving better estimates of future needs. These solutions are consistent with the approach of industry 4.0 initiative.

Procurement 4.0 can be seen as a component of the initiative industry 4.0.[2] But it is much more than this, too. It also offers a new and original

[1] Uusitalo, J. (2019). Strategic Procurement in the Face of Uncertainty. *Master's Thesis*. University of Jyväskylä, Finland.

[2] Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & information systems engineering*, *6*(4), 239–242.

B. Nicoletti, *Procurement 4.0 and the Fourth Industrial Revolution*,
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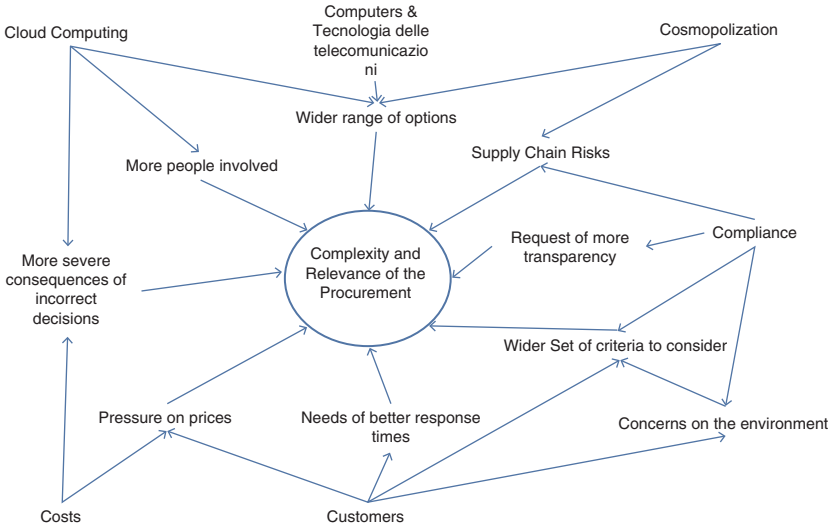

Fig. 1.1 Impact of the transformation on procurement

vision of procurement—one that is more agile, integrated, and responsive to the customers' and the organization's value-adding.

In terms of processes, this book explores problems and solutions in the definition of how procurement can add value for customers, inside and outside of an organization; and how it can help manage relationships, improve processes, and better management of resources, both internal and with partners.[3]

One of the major objectives of the procurement 4.0 initiative is to implement agile procurement. Agility is nowadays a much-used term in the management of organizations.[4] The topic is especially relevant because it is an interesting development: the concept of agile management derived from 'lean management,' which became a business mantra in recent years. The need to be lean is not—in and of itself—the goal that organizations

[3] In this book, the terms 'supplier' and 'vendor' are not used. These are replaced with 'partners,' because if the supply fails both the client and the supplier are damaged.

[4] Nicoletti, B. (2017), *Agile Procurement. Volume II: Designing and Implementing a Digital Transformation*, Springer International Publishing, London, UK, ISBN 978-3-319-61085-6.

must pursue; rather, it is a means to becoming more agile and flexible. In other words, agility is the objective for which leanness is the means.

This vital need for agility is a consequence of the turbulence of the current environment. An agile enterprise can respond quickly to changes in the economy, markets, and technology.

In order to be agile, organizations must be able to respond quickly to changes by adapting their configuration. Better organizational agility can be achieved by maintaining and adapting products and services to meet the needs of customers. This can be done by adjusting the organization and making the best use of available resources within the ecosystem in which the organization operates. Thanks to its agility, an organization can quickly adapt to market changes and the evolving environment in effective, efficient, and economical ways.

In a scenario of this type, it is important that the procurement function fits the organizational philosophy. To achieve this, there are essentially two approaches that should be followed simultaneously. One is to improve processes by adopting a lean approach, while at the same time management should be automated, to implement effective, efficient, and economical solutions. Procurement 4.0 is an extension of these concepts. It is based on the key principles of complex adaptive systems and complexity science. This approach creates the basis for success. One can say that the agility of procurement in an organization result of its intelligence.

Procurement 4.0 is geared to supporting the digital transformation of an organization. It aims to turn such responsiveness and change into a habit of an organization's life. It intends to reduce or eliminate the organizational trauma that paralyzes many organizations when they try to adapt to new markets, environments, and solutions. Change is perpetual: procurement 4.0 must be able to easily adapt and take advantage of emerging opportunities. Moreover, procurement 4.0 is an integral and essential component of a larger system within a given organization. Its activities produce and support digital processing chain effects both within procurement and in the wider organization.

This book delves deep into these methodologies and techniques, treating the field of procurement 4.0 as an agile business model and involving all its components.[5]

[5] Nicoletti, B. (2017), *Agile Procurement. Volume II: Designing and Implementing a Digital Transformation*, Springer International Publishing, London, UK, ISBN 978-3-319-61085-6.

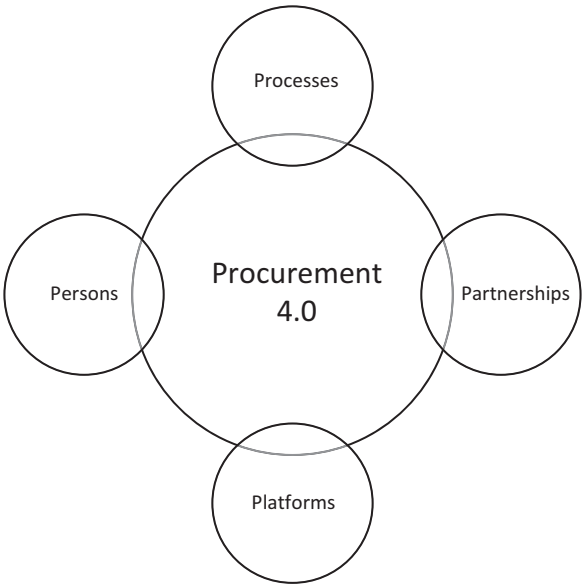

Fig. 1.2 Four Ps

The transformation of organizations must cover key success factors, which are summarized in this book as the four Ps (Fig. 1.2):

- Processes
- Platforms
- Persons
- Partnerships.

The central chapters in this book follow the sequence of these four Ps. The final part is a discussion of the future of procurement 4.0.

The core thesis that this book promulgates is that the function, discipline, and activity of procurement 4.0 can be a critical and strategic interface within operations management, supporting organizational efficiency, effectiveness, and economics as part of a long-term perspective. This is demonstrated through a number of references to real organizations in different sectors.

Nicoletti, B. (2017), *Agile Procurement. Volume I: Adding Value with Lean Processes*, Springer International Publishing, London, UK. ISBN 978-3-319-61082-5.

CHAPTER 2

Industry 4.0 and Procurement 4.0

2.1 Introduction

A saying attributed to Darwin argues that "[it] is not the strongest of the species that survives nor the most intelligent, but one best responsive to change."[1] This also applies to organizations. They need to renew themselves, otherwise they will be marginalized or bypassed.

This chapter discusses the increasing application of innovation in procurement. Such renewal can be labeled 'procurement 4.0.'

Industry 4.0 is the convergence of information and communication technology (ICT) and automation of machinery and infrastructure. The term refers to a Fourth Industrial Revolution. This is distinguished by advanced digitization within organizations, based on the integration of ICT solutions with operational technologies in the field of intelligent objects (machines and products).[2] This enables and transforms industrial production systems and services independently to control their production processes. In addition to the focus on digitization and automation, industry 4.0 provides support for the interaction of technology innovations whose quantitative effects allow organizations to create new products, processes, modes of production, and business models.

[1] Huxley, T. H. (2018). *The Darwinian hypothesis*. Amazon Digital Press LLC, Bellevue, WA.

[2] Piggin, R. (2014). Industrial systems: cyber-security's new battlefront [Information Technology Operational Technology]. *Engineering & Technology*, *9*(8), 70–74.

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Innovation is necessary for organizations to face new challenges. It is also essential to improving the effectiveness, efficiency, and economics of the procurement sector and to meet the growing need to add value and satisfy customers through all functions of an organization. There is a concomitant need to improve relations with the ecosystem of the organization and its partners. If the partners are not satisfied, an organization cannot create effective partnerships in an extended value network perspective. This book stresses the move from the concept of a value chain to a value network, and this term is used throughout.[3] The value for customers and the organizations is obtained through an ecosystem that combines vendors, customers, and public administration elements in a network organization.

The innovation goals can be summarized in three aspects[4]:

#1. Smarter sourcing (fewer transactions and more value in each of them). This involves:
- focusing on major spending areas
- consolidating vendors and turning them into partners
- delegating administration and focusing on high value-added activities
- managing critical and direct purchases
- governing a marketplace for indirect purchases with emphasis on self-service by the different functions of the organization.

#2. Making savings in the organization's resources:
- creating centers of excellence in procurement where it makes sense to do so
- optimizing the relationship with partners
- outsourcing where the benefits/cost ratio is bigger.

[3] The term value network has also been used with a different meaning. It was proposed by Stabell and Fjeldstad (Stabell, C.B., Fjeldstad, Ø. D. (1998) and refers there to Configuring value for competitive advantage on chains, shops, and networks: *Strategic Management Journal*, 19(5), 413–437). It is based on mediation technologies according to Thompson's typology (Thompson, J. D. (2017). *Organizations in action: Social science bases of administrative theory.* Routledge, London, UK). It connects clients and customers who are interested in creating mutual relations and interdependence. The mediating technologies support relations between actors scattered across time and space. This model is similar to what has been called the platform approach (Zhu, F., & Iansiti, M. (2007). *Dynamics of platform competition: Exploring the role of installed base, platform quality and consumer expectations.* Division of Research, Harvard Business School, Cambridge, MA).

#3. Maximum utilization of the potential of new solutions:
- standardize
- Innovative use of new solutions such as cloud computing, the Internet of Things (IoT), mobile data, big data analytics, especially in the field of operations.

To move in these directions, it is important to push for better governance of procurement processes and to define a renewal plan to:

- better reflect the priorities of an organization;
- be more accessible to the entire organization;
- create efficiencies and commit to making savings for the organization.

Enel Global Procurement[5]

Enel S.p.A. is an Italian multinational energy company. Its business is in the sectors of electricity generation and distribution. It is also active in the distribution of natural gas. The organization of procurement in the Enel Group has been completely overhauled to increase the Group's economies of scale in terms of sourcing power and procurement intelligence. The objective is to ensure a competitive advantage for Enel in a challenging energy market that is in constant evolution. Particular attention was paid to training. Although part of the Central Procurement Directorate budget, this has been mostly directed to business users, due to the importance of internal customers' use of procurement and their involvement in procurement processes.

Similar care has been paid to partners. Enel organizes a 'supplier day' and webinars to illustrate the launch of new tenders. The main objective of these initiatives is to work in a more integrated way with partners. The supplier day promotes and strengthens relationships with Enel's best partners and, at the same time, creates an opportunity to get to know new partners. Webinars allow the organization to maintain and strengthen mutual understanding.

(*continued*)

[4] Hammer, M., & Champy, J. (2009). *Reengineering the Corporation: Manifesto for Business Revolution, A*. Zondervan, Grand Rapids. MI.

(continued)

A supplier day begins with an update on the overall situation of the markets in which Enel operates, on the organizations within the Enel Group, as well as with detailed information on future short- and medium-term projects. The Enel Group's global procurement arm presents the work of its organization based on global and local categories of goods and services, and informs partners on the qualification processes and vendor evaluation—at the same time updating them about new products being introduced. For example, this has taken place alongside the adoption of a system of electronic tenders and the introduction of a portal for partner qualification.

These events are also an opportunity for an open and transparent discussion during a specific Questions & Answers session. The objective is to get feedback from partners on their overall experience of collaboration with the Enel Group. Each event ends with awards for the Best Partner for the previous year in different categories. This is another way to strengthen successful partnerships.

2.2 Industry 4.0

The term 'industry 4.0' was used for the first time in 2011 when an association of representatives from industry, politics, and academia promoted the idea as an approach to improve the competitiveness of German manufacturing.[6] The German government has supported the idea, announcing that industry 4.0 is an integral part of its initiative High-Tech Strategy 2020 Fuer Deutschland.[7] Subsequently, a working group on industry 4.0 developed the first recommendations for its implementation, published in April 2013.[8]

Industry 4.0 is a term that sets out a vision of the future: the so-called smart factory. It requires and facilitates also an agile and effective procurement 4.0. Industry 4.0 can be defined as the incorporation and manage-

[5] https://corporate.enel.it/it/storie/a/2018/02/open-innovation-meeting-ambrosetti-club-enel-roma. Accessed March 10, 2019.

[6] Schwab, K. (2017). *The fourth industrial revolution*. Currency. London, UK.

[7] Hermann, M., Pentek, T., & Otto, B. (2016, January). Design principles for industrie 4.0 scenarios. In *2016 49th Hawaii international conference on system sciences (HICSS)* (pp. 3928–3937). IEEE.

ment of intelligent products in the realm of physical processes, management, and information/digital. These physical processes in industry 4.0 interact with each other and across geographies and organizations.[9]

Industry 4.0 provides support in two basic directions of development. On the one hand, an application must be 'pulled' by the customer, inducing a change in operating conditions and in the model. This first aspect leads to changes not only in the organization but also social, economic, and political shifts. The most important of these are the following:

- A high capacity for innovation is an important success factor. The goal is customized sales. Over time, customers are granted an opportunity to define the terms of purchase. This trend leads to increasing customization of products. The final objective is a lot size of production of just one item.
- Because of market characteristics, agility is essential in all the operations of an organization, to allow flexibility and maximize the capacity to be adaptive.
- To meet the new requirements of the business model, faster decision-making procedures are needed. Organizational structure must therefore be as flat as possible.
- There should be a boost for economic and ecological efficiency for the production, in the management of costs associated with resources, as well as social awareness on sustainability issues.
- Industry 4.0 pushes the whole society toward innovation.

On the other hand, there is a push for new solutions—such as mobility, 3D printers, mobile computers, advanced computer applications, and so on. They are becoming more and more popular and accessible. In industrial practice, these innovative solutions are still not widely used, but these innovations allow:

- Reduction of human physical labor and the adoption of more automated solutions. Examples are automated guided vehicles (AGV) with the paths programmed in the factory or 'pulled' from another machine or from the product itself;
- New solutions such as simulation, artificial intelligence (AI), digital security, or virtual reality (VR) are guided by the increasing digitization of all production and the availability of advanced tools. Similarly, there

[8] Hermann, M., Pentek, T., & Otto, B. (2016, January). Design principles for industrie 4.0 scenarios. In *2016 49th Hawaii international conference on system sciences* (HICSS). IEEE, 3928–3937.

is now a more extensive network of technical and integrated components. Software allows organizations to collect and analyze data from sensors or tags attached to the goods, and then trace the goods within the factory. It is even possible for an organization to monitor, manage, and maintain its products at customer sites[10];

- Miniaturization to reduce the space necessary for computing devices, while devices with improved performance can be installed in a small space. Nanotechnology is becoming increasingly used.[11] This enables new fields of application, even in the procurement industry.

In short, industry 4.0 describes the integration of technology, ICT, and automation in support of developments in production systems and consequently in procurement processes. These developments have implications for technology and process, organization, and work.[12]

Investment in industry 4.0 is increasingly based on the value of the entire network. What becomes clear is that organizations from all sectors are focusing their investments in the optimization of procurement systems, emphasizing the importance of optimal management thereof in the Fourth Industrial Revolution.

Research on the development, application, and challenges of industry 4.0 was carried out in 2015. This involved 235 German companies in the field of manufacturing, engineering, the automobile industry, electronics, and ICT.[13] The study shows that surveyed companies will be investing an average of 3.3% of their revenues in industry 4.0 by 2020. These investments pertain to key areas in the value network: supply chains, product development, planning, production, services, and distribution. It is expected that 80% of the value network will be digitalized by 2020, with productivity increased by 18% and about €110 billion revenue generated per annum.[14]

[9] Härting, RC, Schmidt, R., Möhring, M., Reichstein, C., Neumaier, P., & Jozinovic, P. (2015). *Nutzenpotenziale von Industries 4.0: Einblicke Aktuelle Studienergebnisse*. BOD-Books on Demand.

[10] Nicoletti, B. (2009), Sintesi Seminario RFID per l'Impiantistica, *L'Impiantistica Italiana*, N. 6, November–December, 1–7.

[11] Porter, A. L., Youtie, J., Shapira, P., & Schoeneck, D. J. (2008). Refining search terms for nanotechnology. *Journal of nanoparticle research*, 10(5), 715–728.

[12] Lasi, H., Fettke, P., Kemper, HG, Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, 6 (4), 239.

[13] Geissbauer, R., Schrauf, S., Koch, V., & Kuge, S. (2014). Industry 4.0 – Opportunities and Challenges of the Industrial Internet, *PwCIL*, Germany. www.pwc.de/industry4.0.

Barilla[15]

Barilla, the premium Italian pasta company, built the largest automated warehouse in the world through the use of LGV (laser-guided vehicle) technology, in Pedrignano, Italy. The warehouse is on the historic site of the group, on the outskirts of Parma, Italy. It serves several Barilla factories and partners. With an area of 40,000 square meters, 80,000 pallets, 120 trucks loaded every day, and 54 wagons with the new LGV, the Barilla warehouse is an example of excellence in global logistics. Barilla aims to improve the services it offers customers (in particular, to large retails chain organizations) and then to be more competitive in its market.

This warehouse will handle a quarter of global material and components for Barilla and nearly half of all the pasta and sauces manufactured by the company and sold around the world, from Brazil to Japan. This structure relies heavily on LGV technology applied for trolleys used to move, store, and pick up goods, and for the supervision of the installation software. The vehicles move without the need for wires or traces. They use sophisticated software that identifies orders, looks for the location of the correct pallet store, or withdraws in real time, and interacts with the vehicles using a radio frequency network.

The structure—which required investment of nearly €15 million—is also a model of energy and environmental efficiency. It has eliminated about 3000 trips a year to external warehouses, reducing carbon dioxide emissions, as well as cutting 40% of lighting costs and 20% of heating and cooling costs.

Accessed July 20, 2019.

[14] Geissbauer, R., Schrauf, S., Koch, V., & Kuge, S. (2014). Industry 4.0 – Opportunities and Challenges of the Industrial Internet, *PwCIL*, Germany. www.pwc.de/industry4.0.

Ocado[16]
Ocado is a British internet supermarket. It specializes in groceries, home essentials, and more delivered to the customer's home. It has a fully automated warehouse where autonomous robots collect products ordered by customers, then pack and pass them to drivers for delivery.[17] In the next step, a dedicated AI application recommends optimal delivery routes. The benefits include reduced labor costs, acceleration, and optimization of processes. There is also an improvement in stock turnover, increased effectiveness of warehouse space (there is no need to create paths for staff), and improved safety.

Figure 2.1 shows the industry 4.0 environment as a synthesis between ICT and automation. This section focuses on methods of procurement 4.0 to provide support.

2.2.1 The Main Components

Industry 4.0 includes a set of solutions enabling intelligent products and processes integrated with interconnected digital and physical components. All this is changing products, processes, business models, organizations, and procurement significantly.[18]

It is possible to define a model for industry 4.0. It consists of several components, which for mnemonic reasons are listed in this book under words with the initial C. The model considers a classification of the industry 4.0 components into 'hard' and 'soft.' Hard components are based on infrastructure; soft components are more oriented toward software. For each, it is possible to show a solution capable of supporting its implementation within an industry 4.0 initiative. All these components require strict management tools (or Command, to continue with words starting with C), which in turn should be supported by specific solutions.

Accessed July 20, 2019.

[15] http://distribuzionemoderna.info/notizia-del-giorno/barilla-inaugura-a-pedrignano-il-piu-grande-magazzino-automatico-del-mondo. Accessed September 15, 2018.

[16] https://www.ocado.com/webshop/startWebshop.do. Accessed August 12, 2019.

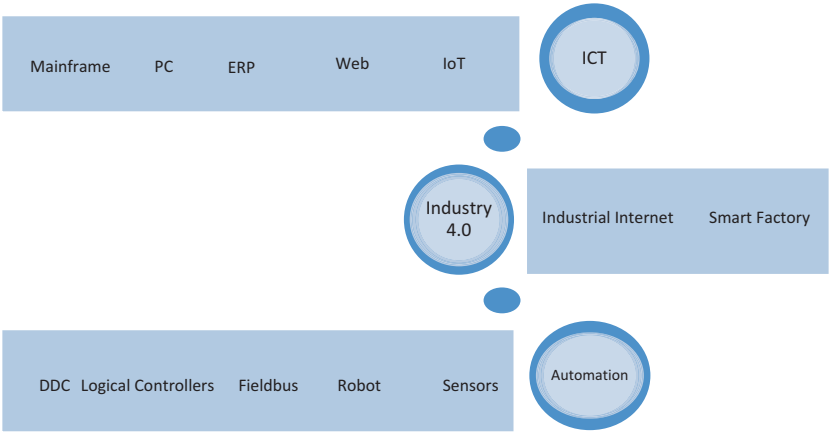

Fig. 2.1 Industry 4.0

Soft

- Collaboration refers to the need to have all machines, robots, and operators working together. Applications such as ERPs (enterprise resource planning) are useful to provide support that is as automated as possible to all management and operational processes. The cyber-physical system (CPS) includes automatic sensors and actuators used to collect and send data.
- Controllership refers to the numerical control machines. These are essential to make the system as independent as possible from the need of human operators. Halfway between cybernetics and control, are robots and AGVs. These advanced automated devices are critical to industry 4.0.
- Cybernetics refers to the use of computers, whether they are in a data center or distributed. The CPS describes the unification of the digital world with the real (physical) flows in the processes of procurement and production.[19] This means that the physical stages are accompanied by processes based on computers, using the concepts of digital twin,[20]

[17] Wodecki, A. (2018). *Artificial intelligence in value creation: Improving competitive advantage*. Springer, Cham, Switzerland.

[18] Schmidt, R., Möhring, M., Härting, R. C., Reichstein, C., Neumaier, P., & Jozinović, P. (2015). Industry 4.0-potentials for creating smart products: empirical research results. In the

ubiquitous computing,[21] and pervasive computing.[22] Increasingly, robots and AI systems are used in organizations.

Hard

- Connection is essential to provide integration of all machines. The IoT, or rather the Internet of Everything (IoE), allows human operators to be part of the elements connected in the organization. The IoT is a solution in the CPS that enables communication with other systems and the cyber-physical system. The IoT makes it possible to create networks that incorporate the entire production process. In this way, it is possible to achieve both horizontal and vertical integration. Horizontal integration refers to the integration of ICT applications in different phases of an organization's planning processes, such as incoming or outgoing logistics, or production and commercialization, and between different organizations (value networks).[23] Procurement 4.0 pushes communication and cooperation into the distribution network (outbound logistics), internal organization (inbound logistics), as well as into the network of customers (output supplies). Vertical integration refers to the integration of different hierarchical levels, such as planning, production management, operations, quality control, and so on.
- Communication refers to the need to connect computing devices and all machines in a local area network (LAN) or a wide area network (WAN), normally via the internet, to support communication.
- Cognition is based on intelligent use of data. All information systems, sensors, and numerical controls (all thanks to the integrated connection tools) generate huge amounts of data, referred to as big data. These data should be analyzed and big data analytics is essential in industry 4.0.[24] Data analytics, data mining, and distribution of big data are critical supports for big data analytics. They must be characterized by the nine V characteristics—veracity, variety, velocity, volume, validity, variability, volatility, visualization, and value—needed to process data from

International Conference on Business Information Systems. Springer, Cham, Switzerland: 16–27.

[19] Lee, J., Bagheri, B., & Kao, H. A. (2015). A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing letters*, 3, 18–23.

[20] Schleich, B., Anwer, N., Mathieu, L., & Wartzack, S. (2017). Shaping the digital twin for design and production engineering. *CIRP Annals*, *66*(1), 141–144.

[21] Lyytinen, K., & Yoo, Y. (2002). Ubiquitous computing. *Communications of the ACM*, 45 (12): 63–96.