UNIWERSYTET EKONOMICZNY W KRAKOWIE

Faculty of Materials, Metallurgy and Recycling

Faculty of Mechanical Engineering

Tomas Bata University

Improving quality management teaching in the era of Industry 4.0

Cracow University of Economics, Poland
Technical University of Košice, Slovakia
Tomas Bata University in Zlín, Czechia

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Evaluation of competence needs in the enterprises

supported by
Visegrad Fund

Kraków – Košice – Zlín 2023

Information about project partners

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Table of contents

Introduction

The aim of the first part of the project was to obtain the necessary information on the extent of use of I4.0 tools in enterprises and to assess their applicability in the field of Q4.0 management. The obtained and processed results of the structured questionnaire will serve to create a framework for increasing the awareness and competence of employees of organizations and improving the quality of education at universities. The questionnaire follows the results from the output "Analysis of the current state of knowledge about quality 4.0". The motivation for its development was the definition (ASQ, 2020): "Q4.0 combines advanced digital technologies I4.0 with perfect quality to achieve significant performance and improve efficiency.

The questionnaire structure accepts the PDCA cycle for management systems improvement requirements. In addition to the initial informative questions focused on the level of implementation of I4.0 in the organization, the framework for investigating the implementation of Q4.0 management tools was created to be in accordance with the structure of management systems (from Chapters 4 to 10).

The prerequisite for choosing such an approach were at least the following factors:

1. The quality management system (ISO 9001, or in the automotive industry also IATF 16949) is the most represented in organizations.
2. The basic structure in most management systems accepts HLS (High Level Structure) as one of the basic prerequisites for their integration (Integration Management System).
3. I4.0 tools (technological) are implemented in organizations to improve specific processes and areas of management.

A total of 16 organizations participated in the survey, 6 from Slovakia, 6 from the Czech Republic and 4 from Poland. Regarding the industry sector, the most represented was the automotive industry (approx. 63%), then the steel industry (13%) and the food industry (6%), the rest of the respondents were from other industry sector (approx. 18%).

Chapter 1. Questionnaire basic info

Questionnaire framework is based on the structure of the ISO 9001:2015 requirements, which has an HLS structure and it is linked with the I4.0 pillars (Nenadál, 2022; Fonseka, 2021), what enabled to assess the level of I4.0/Q4.0 implementation. Due to the fact that each of the respondent organizations is at the different level of I4.0 implementation, there are 5 levels offered as answers 0/A/B/C/D and organization could choose the most relevant answer, as follows:

0 - we do not plan to implement the elements (pillars) of the I 4.0 concept in this area.

A - we plan to implement elements (pillars) of the I 4.0 concept in this area.

B - we implement the elements (pillars) of the I 4.0 concept in this area.

C - we have implemented the elements (pillars) of the I 4.0 concept in this area but not completely.

D - the elements (pillars) of the I 4.0 concept are fully implemented in this area.

Requirements for sustainability are added value transferred to the management systems in the organization (Kóča, 2023). For this reason, this area was investigated through answers to the question: "Does the organization address sustainability requirements or CSR (Corporate Social Responsibility) when managing its processes and use appropriate digital tools (elements, pillars of I4.0) for this purpose?"

The assessment of the level of application of modern quality management and its tools assumed the introduction of the basic 9 pillars of I4.0 in the organization. Therefore, part of the questions in relation to the functioning of Q4.0 in the organization was to evaluate which technological pillars does the organization implement in quality management the most. These were the following pillars (elements of the I4.0 concept):

- ROBOT - Autonomous Robot,
- SIMUL - Simulation/ Augmented reality,
- HVInteg - Horizontal/Vertical Integration,
- IoT - Internet of Things,
- CYBS - Cybersecurity,
- AI - Artificial Inteligence,
- CLOUD, AditM - Additive Manufacturing,
- SupCH - Supply Chain / Block Chain,
- BIGD - Big Data Analytics.

Chapter 2. Data gathering

2.1. Questionnaire structure

Questionnaire (see Figure 1) was divided into 3 main parts:

1. First part included 3 general informative questions about name of the organization, number of employees and type of the organization.
2. The second part included 3 basic questions Q1 - Q3, reflecting organization strategic issues in relation to I4.0.
3. The third part included 37 questions - Q4 – Q40, which were linked with the ISO 9001 requirements.

Multiple choice Sub-question labelled as “SQ” orientated to pillars I4.0 was added to the questions Q2 - Q40.

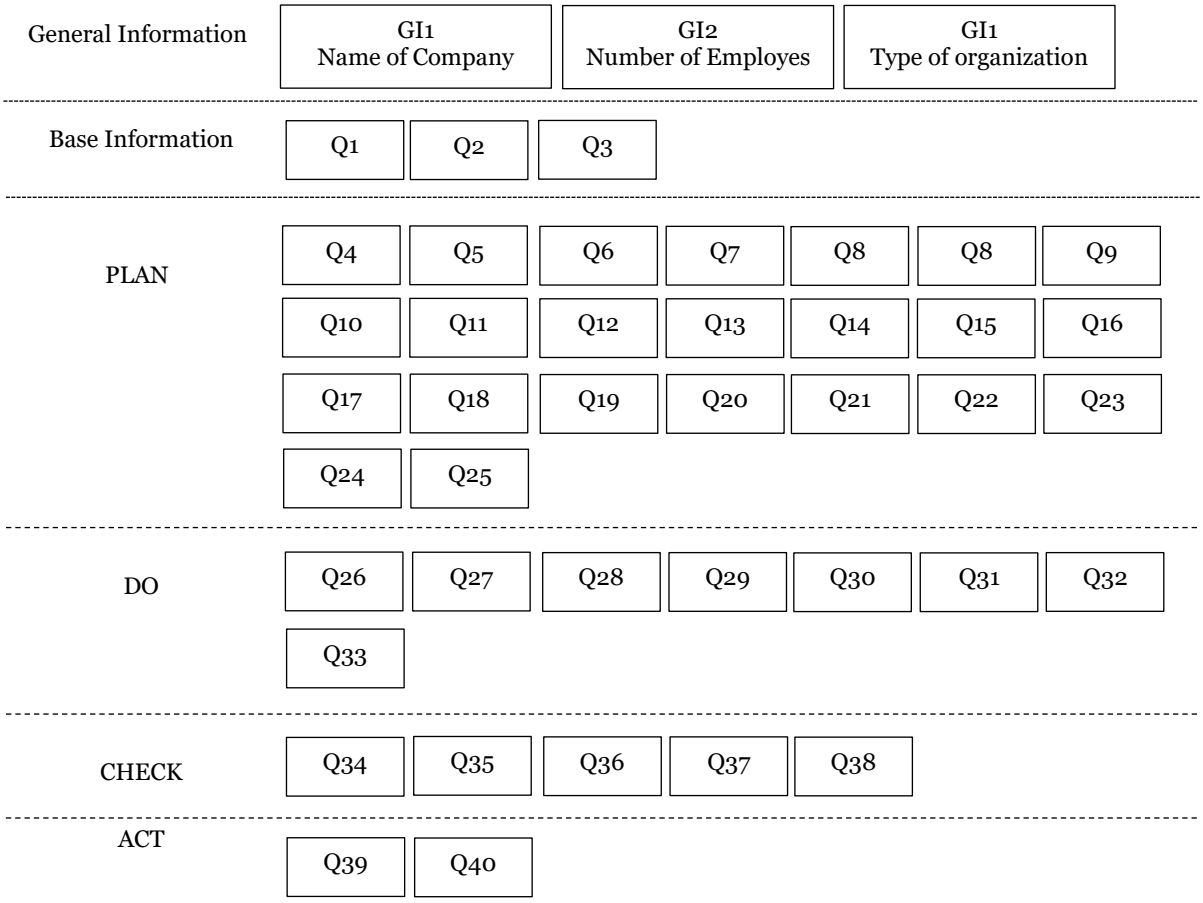
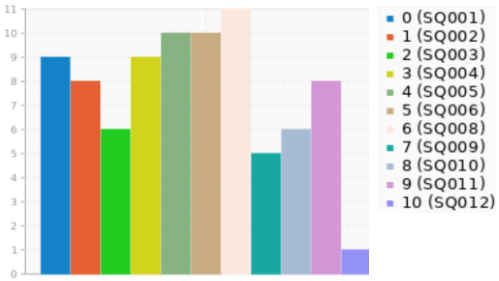


Figure 1. Questionnaire framework

2.2. Base questions

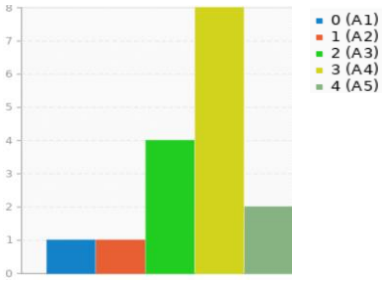
Q1 Which of the I4.0 elements do you use in your organization?

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ001)	9	56,25%
SIMUL - Simulation/ Augmented reality (SQ002)	8	50,00%
HVInteg - Horizontal/vertical Integration (SQ003)	6	37,50%
IoT - Internet of Things (SQ004)	9	56,25%
CYBS - Cybersecurity (SQ005)	10	62,50%
AI - Artificial Intelligence (SQ006)	10	62,50%
CLOUD - (SQ008)	11	68,75%
AditM - Additive Manufacturing (SQ009)	5	31,25%
SupCH - Supply Chain / Block Chain (SQ011)	6	37,50%
BIGD - Big Data Analytics (SQ011)	8	50,00%
None of above (SQ012)	1	6,25%



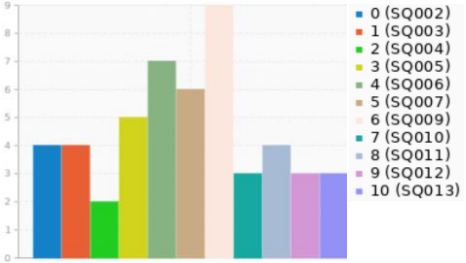
Q2 Does the organization address sustainability requirements or CSR (corporate social responsibility) when managing its processes and use appropriate digital tools (elements, pillars of I4.0) for this purpose?

Answer	Count	Percentage
0 (A1)	1	6,25%
A (A2)	1	6,25%
B (A3)	4	25,00%
C (A4)	8	50,00%
D (A5)	2	12,50%



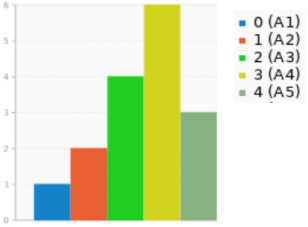
SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/ Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	5	31,25%
CYBS - Cybersecurity (SQ006)	7	43,75%
AI - Artificial Intelligence (SQ007)	6	37,50%
CLOUD - (SQ009)	9	56,25%
AditM - Additive Manufacturing (SQ010)	3	18,75%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
IGD - Big Data Analytics (SQ012)	3	18,75%
None of above (SQ013)	3	18,75%



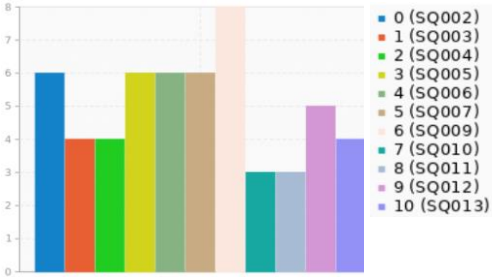
Q3 Is the implementation of I4.0 elements/pillars in the management system(s) part of the organization's strategy? (Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	1	6,25%
A (A2)	2	12,50%
B (A3)	4	25,00%
C (A4)	6	37,50%
D (A5)	3	18,75%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	6	37,50%
SIMUL - Simulation/ Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	6	37,50%
CYBS - Cybersecurity (SQ006)	6	37,50%
AI - Artificial Intelligence (SQ007)	6	37,50%
CLOUD - (SQ009)	8	50,00%
AditM - Additive Manufacturing (SQ010)	3	18,75%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	4	25,00%

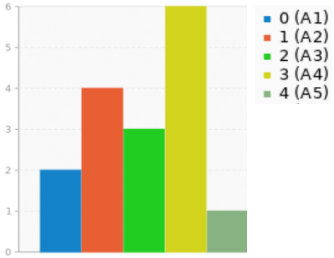


2.3. Questions related to the PLAN

Understanding the organization and its context

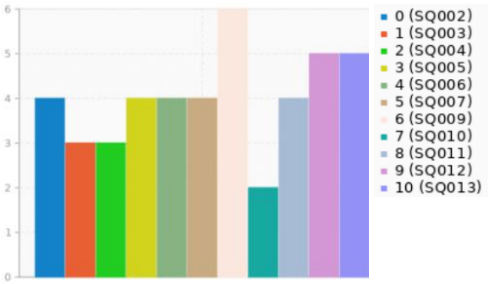
Q4 Does the organization use a certain level of implementation of I4.0 elements/pillars when determining internal or external aspects and relationships within the QMS? (Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	4	25,00%
B (A3)	3	18,75%
C (A4)	6	37,50%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

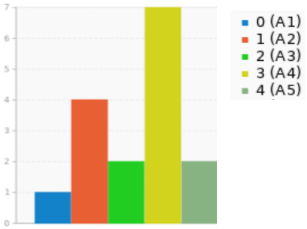
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/ Augmented reality (SQ003)	3	18,75%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Inteligence (SQ007)	4	25,00%
CLOUD (SQ009)	6	37,50%
AditM - Additive Manufacturing (SQ010)	2	12,50%
SupCH - Supply Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	5	31,25%



Understanding the needs and expectations of interested parties

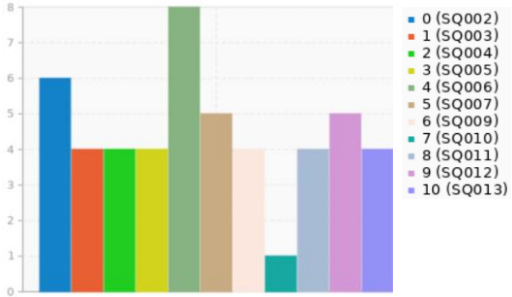
Q5 Does the organization understand and take into account expectations and needs of interested parties related to digitalization of processes and products and implementation of I4.0 elements within QMS?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	1	6,25%
A (A2)	4	25,00%
B (A3)	2	12,50%
C (A4)	7	43,75%
D (A5)	2	12,50%



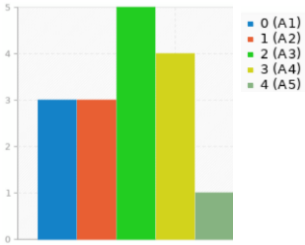
SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	6	37,50%
SIMUL - Simulation/ Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	8	50,00%
AI - Artificial Intelligence (SQ007)	5	31,25%
CLOUD (SQ009)	4	25,00%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	4	25,00%



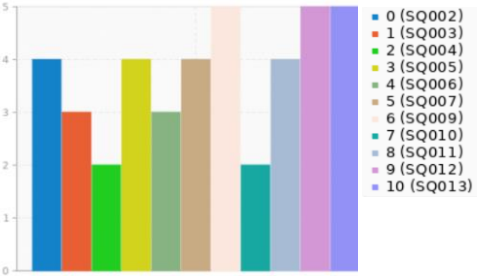
Q6 Does the organization use a certain level of implementation of I4.0 elements/pillars in determining the subject matter (scope) of the QMS?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	3	18,75%
B (A3)	5	31,25%
C (A4)	4	25,00%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/ Augmented reality (SQ003)	3	18,75%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	4	25,00%
CLOUD (SQ009)	5	31,25%
AditM - Additive Manufacturing (SQ010)	2	12,50%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	5	31,25%

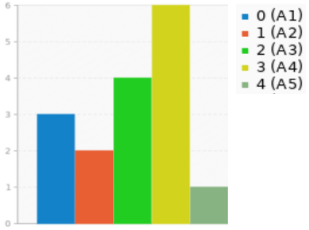


Quality management system and its processes

Q7 Does the organization use a certain level of implementation of I4.0 elements/pillars in determining inputs, outputs, resource allocation, process implementation, and improvement, as well as in setting KPIs?

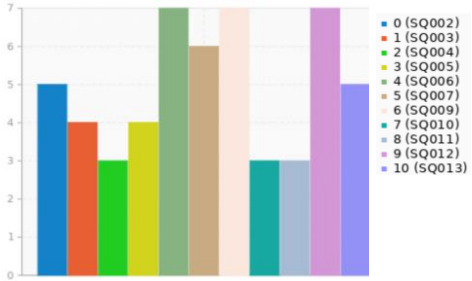
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	2	12,50%
B (A3)	4	25,00%
C (A4)	6	37,50%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

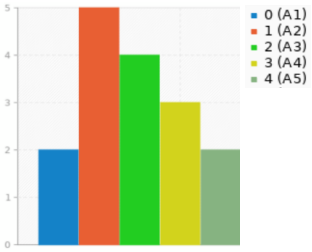
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	5	31,25%
SIMUL - Simulation/ Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	7	43,75%
AI - Artificial Intelligence (SQ007)	6	37,50%
CLOUD (SQ009)	7	43,75%
AditM - Additive Manufacturing (SQ010)	3	18,75%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	5	31,25%



Q8 Does the organization use a certain level of implementation of I4.0 elements/pillars in managing risks and opportunities?

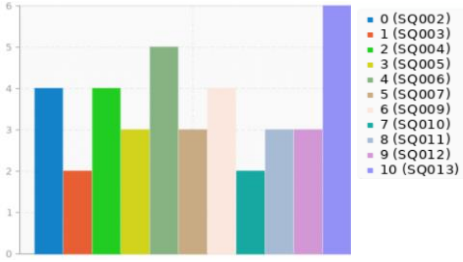
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	5	31,25%
B (A3)	4	25,00%
C (A4)	3	18,75%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

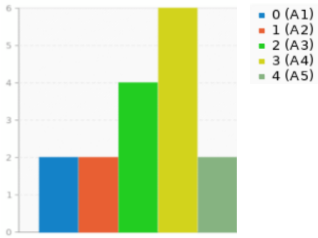
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/ Augmented reality (SQ003)	2	12,50%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	5	31,25%
AI - Artificial Intelligence (SQ007)	3	18,75%
CLOUD (SQ009)	4	25,00%
AditM - Additive Manufacturing (SQ010)	2	12,50%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	3	18,75%
None of above (SQ013)	6	37,50%



Leadership and commitment

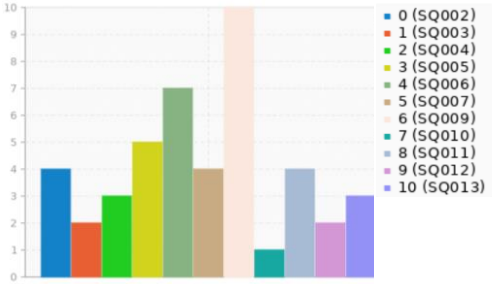
Q9 Does the organization support cross-functional responsibility for quality and empowerment via shared/connected information and collaboration?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	2	12,50%
B (A3)	4	25,00%
C (A4)	6	37,50%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

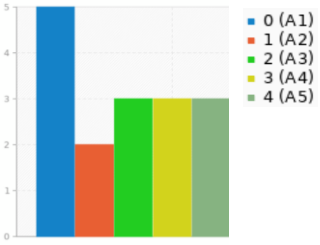
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/ Augmented reality (SQ003)	2	12,50%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	5	31,25%
CYBS - Cybersecurity (SQ006)	7	43,75%
AI - Artificial Intelligence (SQ007)	4	25,00%
CLOUD (SQ009)	10	62,50%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	2	12,50%
None of above (SQ013)	3	18,75%



Customer Focus

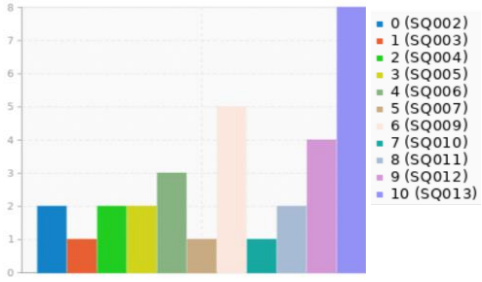
Q10 Does the organization use a certain level of implementation of I4.0 elements/pillars when measuring employee satisfaction?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	5	31,25%
A (A2)	2	12,50%
B (A3)	3	18,75%
C (A4)	3	18,75%
D (A5)	3	18,75%



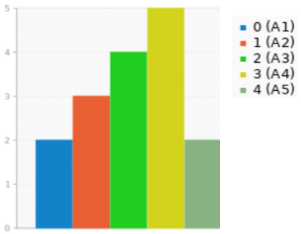
SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	2	12,50%
SIMUL - Simulation/Augmented reality (SQ003)	1	6,25%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	2	12,50%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	1	6,25%
CLOUD (SQ009)	5	31,25%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	4	25,00%
None of above (SQ013)	8	50,00%



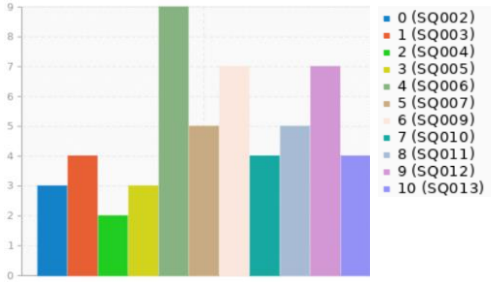
Q11 Does the organization use some level of implementation of I4.0 elements/pillars in understanding customer requirements - e. g. big data and advanced analytics, customer platforms?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	3	18,75%
B (A3)	4	25,00%
C (A4)	5	31,25%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

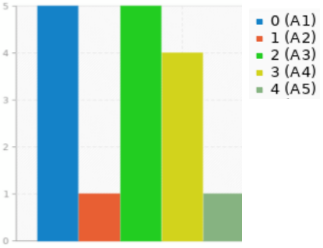
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	9	56,25%
AI - Artificial Intelligence (SQ007)	5	31,25%
CLOUD (SQ009)	7	43,75%
AditM - Additive Manufacturing (SQ010)	4	25,00%
SupCH - Supply Chain / Block Chain (SQ011)	5	31,25%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	4	25,00%



Establishing the quality policy

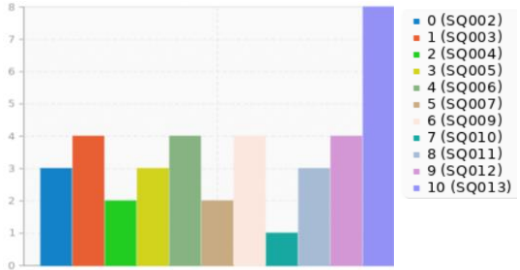
Q12 Does the quality policy involve the field of digitalization of quality and implementation of Industry 4.0 elements into QMS?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	5	31,25%
A (A2)	1	6,25%
B (A3)	5	31,25%
C (A4)	4	25,00%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

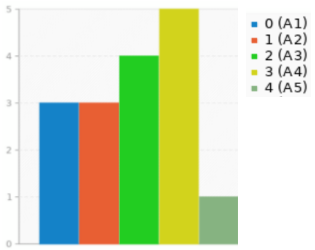
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	4	25,00%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	4	25,00%
None of above (SQ013)	8	50,00%



Organizational roles, responsibilities and authorities

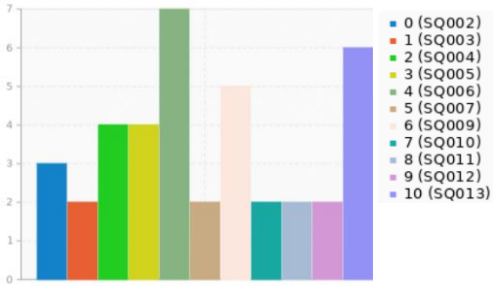
Q13 Does the organization use a certain level of implementation of the I4.0 elements/pillars when assigning responsibilities and authorities?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	3	18,75%
B (A3)	4	25,00%
C (A4)	5	31,25%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

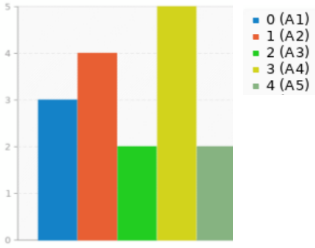
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	2	12,50%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	7	43,75%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	5	31,25%
AditM - Additive Manufacturing (SQ010)	2	12,50%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	2	12,50%
None of above (SQ013)	6	37,50%



Actions to address risks and opportunities

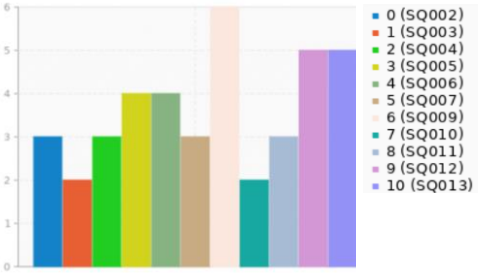
Q14 Does the organization use a certain level of implementation of I4.0 elements/pillars when validating the effectiveness of risk and opportunities management measures?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	4	25,00%
B (A3)	2	12,50%
C (A4)	5	31,25%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

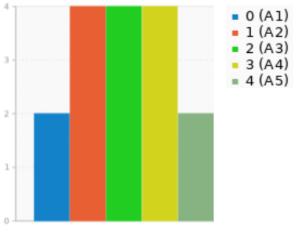
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	2	12,50%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Intelligence (SQ007)	3	18,75%
CLOUD (SQ009)	6	37,50%
AditM - Additive Manufacturing (SQ010)	2	12,50%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	5	31,25%



Quality objectives and planning to achieve them

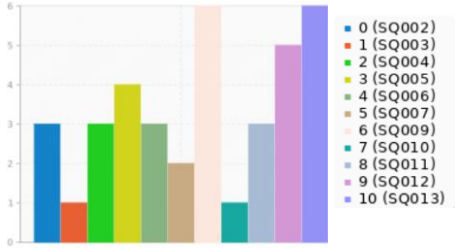
Q15 Does the organization use a certain level of implementation of the I4.0 elements/pillars in developing, monitoring, and communicating Quality Objectives? (Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	4	25,00%
B (A3)	4	25,00%
C (A4)	4	25,00%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

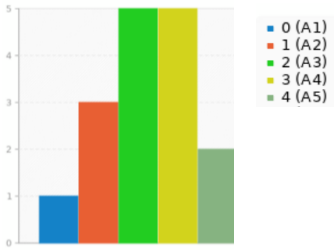
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	1	6,25%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	6	37,50%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	6	37,50%



Planning of changes

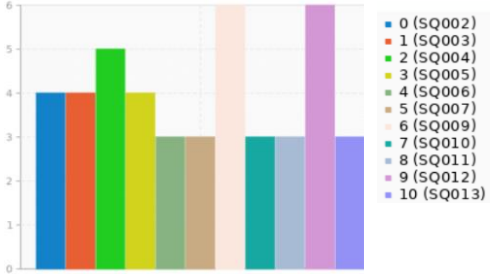
Q16 Does the organization use a certain level of implementation of I4.0 elements/pillars when planning changes and availability of resources for those changes? (Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	1	6,25%
A (A2)	3	18,75%
B (A3)	5	31,25%
C (A4)	5	31,25%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

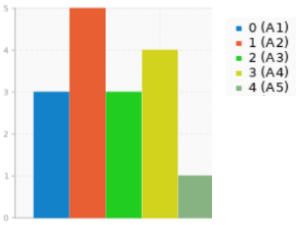
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	5	31,25%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	3	18,75%
CLOUD (SQ009)	6	37,50%
AditM - Additive Manufacturing (SQ010)	3	18,75%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	6	37,50%
None of above (SQ013)	3	18,75%



Resources/General

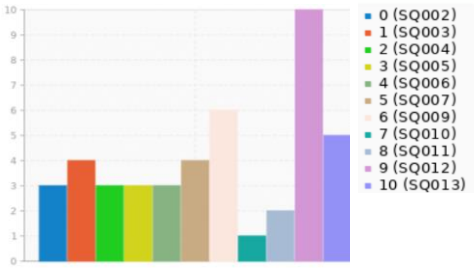
Q17 Does the organization use Industry 4.0 elements (e.g. big data and advanced analytics for diagnostics, prediction and prescription) when identifying and providing resources needed for effective functioning of QMS?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	5	31,25%
B (A3)	3	18,75%
C (A4)	4	25,00%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

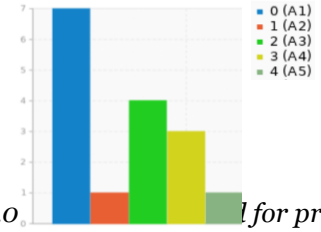
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	4	25,00%
CLOUD (SQ009)	6	37,50%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	10	62,50%
None of above (SQ013)	5	31,25%



People

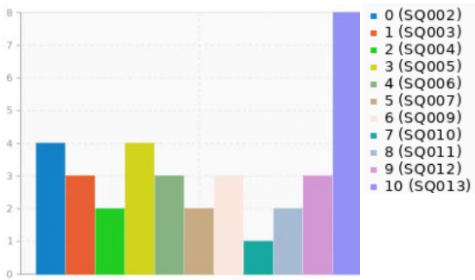
Q18 Does the organization use a certain level of implementation of the I4.0 elements/pillars when identifying and providing the person necessary to effectively implement the QMS?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	7	43,75%
A (A2)	1	6,25%
B (A3)	4	25,00%
C (A4)	3	18,75%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 l for previous question.

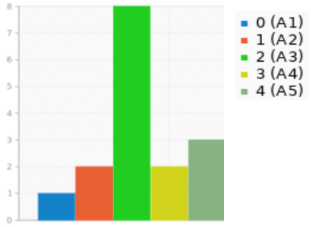
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/Augmented reality (SQ003)	3	18,75%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	3	18,75%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	3	18,75%
None of above (SQ013)	8	50,00%



Infrastructure

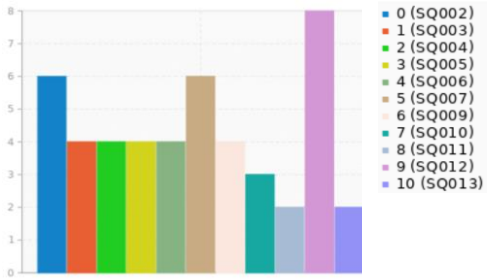
Q19 Does the organization, in identifying, providing, and maintaining the infrastructure necessary to operate and achieve conformity of products and services, use a certain level of implementation of the I4.0 elements/pillars - e. g. predictive maintenance? (Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	1	6,25%
A (A2)	2	12,50%
B (A3)	8	50,00%
C (A4)	2	12,50%
D (A5)	3	18,75%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

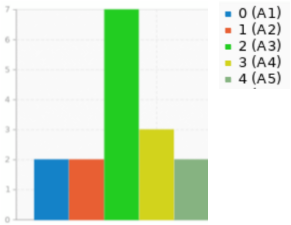
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	6	37,50%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Intelligence (SQ007)	6	37,50%
CLOUD (SQ009)	4	25,00%
AditM - Additive Manufacturing (SQ010)	3	18,75%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	8	50,00%
None of above (SQ013)	2	12,50%



Environment for the operation of processes

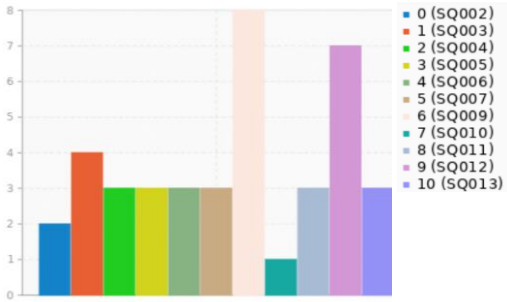
Q20 Does the organization use a certain level of implementation of I4.0 elements/pillars in defining, providing, and maintaining the environment necessary to ensure the operation and conformities of products and services?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	2	12,50%
B (A3)	7	43,75%
C (A4)	3	18,75%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

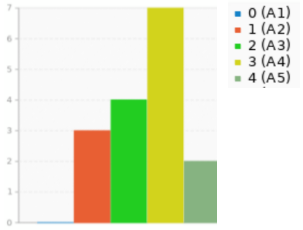
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	2	12,50%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	3	18,75%
CLOUD (SQ009)	8	50,00%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	3	18,75%



Monitoring and measuring resources

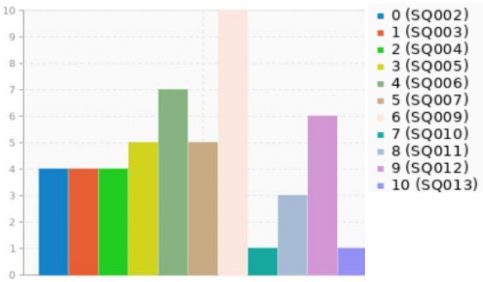
Q21 Does the organization use a certain level of implementation of I4.0 elements/pillars in monitoring and measuring resources to ensure valid and reliable results?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	0	0,00%
A (A2)	3	18,75%
B (A3)	4	25,00%
C (A4)	7	43,75%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

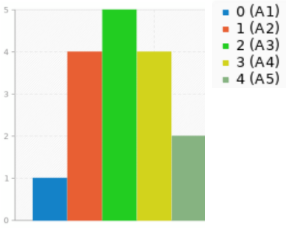
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	5	31,25%
CYBS - Cybersecurity (SQ006)	7	43,75%
AI - Artificial Intelligence (SQ007)	5	31,25%
CLOUD (SQ009)	10	62,50%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	6	37,50%
None of above (SQ013)	1	6,25%



Organizational knowledge

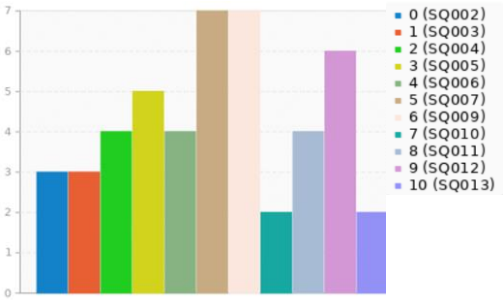
Q22 Does the organization use a certain level of implementation of I4.0 elements/pillars in determining the necessary knowledge to operate its processes and to achieve conformity of products and services?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	1	6,25%
A (A2)	4	25,00%
B (A3)	5	31,25%
C (A4)	4	25,00%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	3	18,75%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	5	31,25%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Intelligence (SQ007)	7	43,75%
CLOUD (SQ009)	7	43,75%
AditM - Additive Manufacturing (SQ010)	2	12,50%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	6	37,50%
None of above (SQ013)	2	12,50%

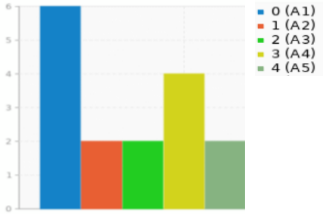


Competence

Q23 Does the organization use a certain level of implementation of I4.0 elements/pillars in determining the competent persons who manage and affects the performance and effectiveness of the QMS?

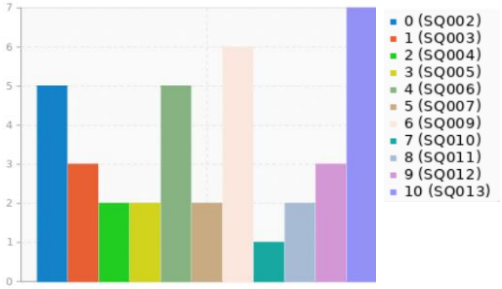
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	6	37,50%
A (A2)	2	12,50%
B (A3)	2	12,50%
C (A4)	4	25,00%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	5	31,25%
SIMUL - Simulation/Augmented reality (SQ003)	3	18,75%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	2	12,50%
CYBS - Cybersecurity (SQ006)	5	31,25%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	6	37,50%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	3	18,75%
None of above (SQ013)	7	43,75%

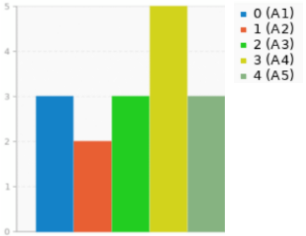


Communication

Q24 Does the organization use a certain level of implementation of I4.0 elements/pillars in determining internal and external communication - e. g. automated collection and sharing of the right data horizontally and vertically (where, what, how, to whom)?

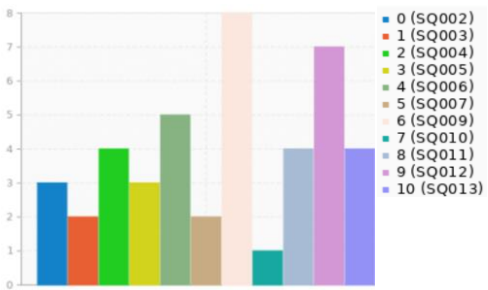
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	2	12,50%
B (A3)	3	18,75%
C (A4)	5	31,25%
D (A5)	3	18,75%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

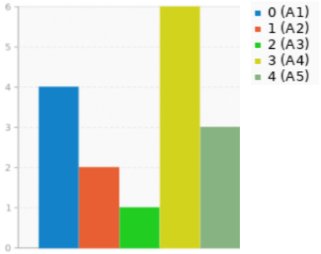
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	2	12,50%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	5	31,25%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	8	50,00%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	4	25,00%



Documented information

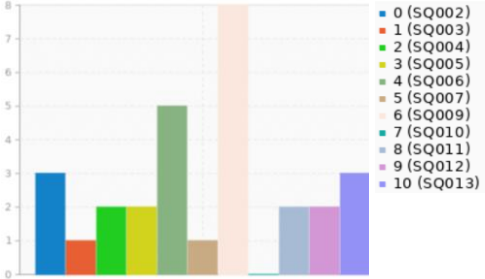
Q25 Does the organization use a certain level of implementation of I4.0 elements/pillars in creating, updating, and managing - e. g. automated documentation control?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	4	25,00%
A (A2)	2	12,50%
B (A3)	1	6,25%
C (A4)	6	37,50%
D (A5)	3	18,75%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	1	6,25%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	2	12,50%
CYBS - Cybersecurity (SQ006)	5	31,25%
AI - Artificial Intelligence (SQ007)	1	6,25%
CLOUD (SQ009)	8	50,00%
AditM - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	2	12,50%
None of above (SQ013)	3	18,75%

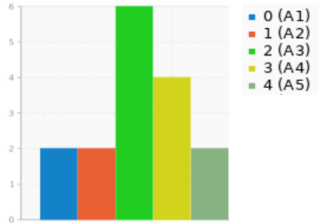


2.4. Questions related to the DO

Operational planning and control

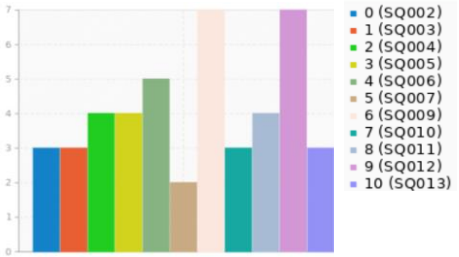
Q26 Does the organization use a certain level of implementation of I4.0 elements/pillars in planning and managing operations (determining product and service requirements, criteria, resources, and documented information - e. g. automated big data flow from products in use)?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	2	12,50%
B (A3)	6	37,50%
C (A4)	4	25,00%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	3	18,75%
HVInteg - Horizontal/Vertical Integration (SQ004)	4	25,00%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	5	31,25%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	7	43,75%
AditM - Additive Manufacturing (SQ010)	3	18,75%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	3	18,75%

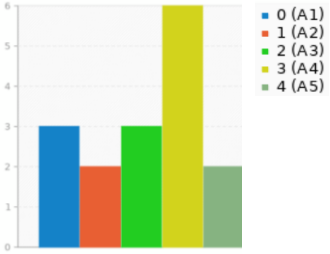


Requirements for products and services

Q27 Does the organization use a certain level of implementation of I4.0 elements/pillars when communicating with customers, determining and reviewing product and service requirements, and changes?

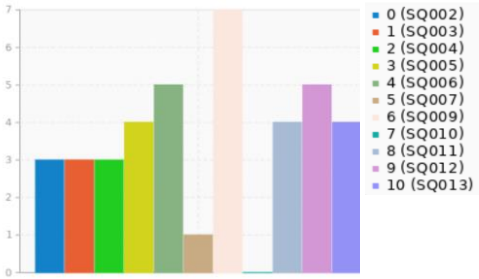
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	2	12,50%
B (A3)	3	18,75%
C (A4)	6	37,50%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	3	18,75%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	5	31,25%
AI - Artificial Intelligence (SQ007)	1	6,25%
CLOUD (SQ009)	7	43,75%
AditM - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	4	25,00%

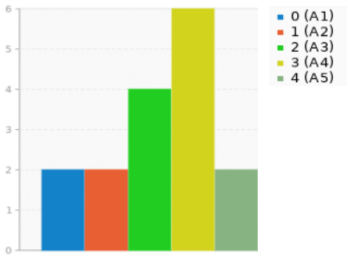


Design and development of products and services

Q28 Does the organization use a certain level of implementation of I4.0 elements/pillars in establishing, implementing, and maintaining the design and development process (specifically in planning and determining inputs, resources, outputs, changes, and necessary documented information - e. g. using automated streams of big data within design, virtual simulation and testing, 3D printing)?

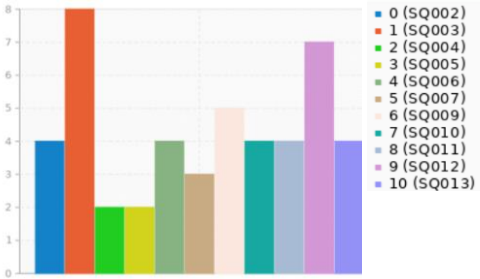
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	2	12,50%
B (A3)	4	25,00%
C (A4)	6	37,50%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

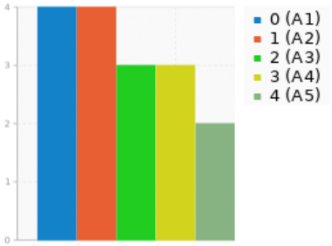
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/Augmented reality (SQ003)	8	50,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	2	12,50%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Intelligence (SQ007)	3	18,75%
CLOUD (SQ009)	5	31,25%
AditM - Additive Manufacturing (SQ010)	4	25,00%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	4	25,00%



Control of externally provided processes, products and services

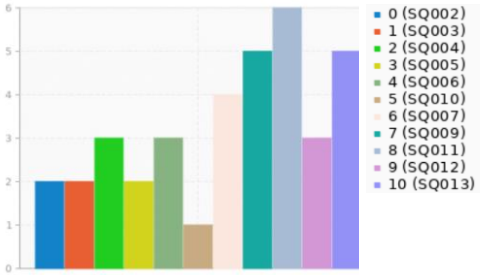
Q29 Does the organization use a certain level of implementation of I4.0 elements/pillars for outsourced processes, products, and services as well as for monitoring and evaluation - e. g. horizontal quality data flow and integration of the supply chain, blockchain for ensuring transparent supply chain and tracking of quality easily?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	4	25,00%
A (A2)	4	25,00%
B (A3)	3	18,75%
C (A4)	3	18,75%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

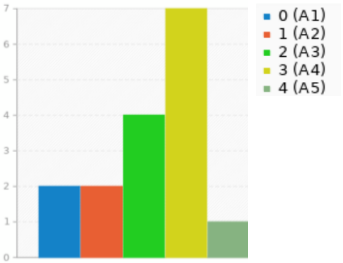
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ001)	2	12,50%
SIMUL - Simulation/ Augmented reality (SQ002)	2	12,50%
HVInteg - Horizontal/vertical Integration (SQ003)	3	18,75%
IoT - Internet of Things (SQ004)	2	12,50%
CYBS - Cybersecurity (SQ005)	3	18,75%
AI - Artificial Intelligence (SQ006)	1	6,25%
CLOUD - (SQ008)	4	25,00%
AditM - Additive Manufacturing (SQ009)	5	31,25%
SupCH - Supply Chain (SQ010)	6	37,50%
BIGD - Big Data Analytics (SQ011)	3	18,75%
None of above (SQ012)	5	31,25%



Product and service provision

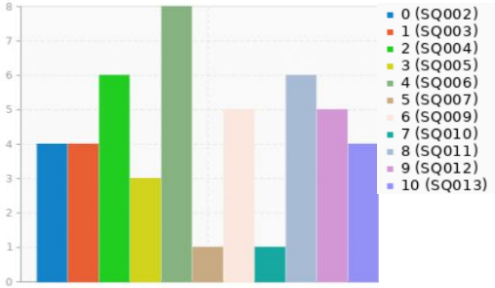
Q30 Does the organization use a certain level of implementation of I4.0 elements/pillars in the production and management of the services provided, in the identification of resources, documented information and the use of appropriate infrastructure?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	2	12,50%
B (A3)	4	25,00%
C (A4)	7	43,75%
D (A5)	1	6,25%



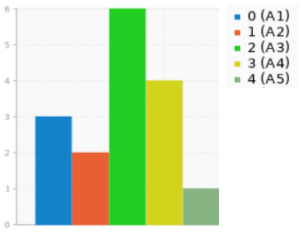
SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	6	37,50%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	8	50,00%
AI - Artificial Intelligence (SQ007)	1	6,25%
CLOUD (SQ009)	5	31,25%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	6	37,50%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	4	25,00%



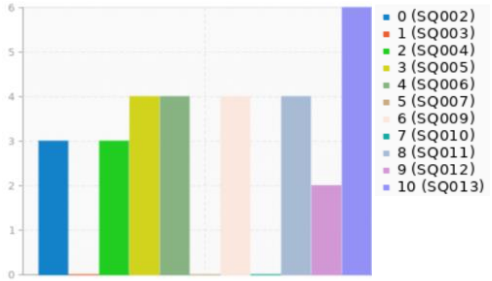
Q31 Does the organization use a certain level of implementation of I4.0 elements/pillars in the production and management of the services provided, specifically in the identification and traceability of assets belonging to customers or external providers, their protection, post-delivery activities, and change management?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	2	12,50%
B (A3)	6	37,50%
C (A4)	4	25,00%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

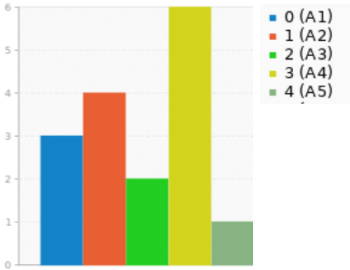
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/Augmented reality (SQ003)	0	0,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	4	25,00%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Intelligence (SQ007)	0	0,00%
CLOUD (SQ009)	4	25,00%
AditM - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	2	12,50%
None of above (SQ013)	6	37,50%



Release of products and services

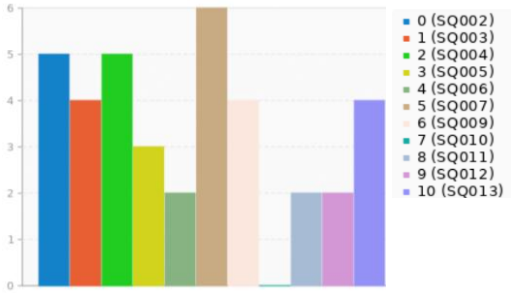
Q32 Does the organization use a certain level of I4.0 element/pillar adoption when releasing products and services - e. g. automated quality inspection, machine vision?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	4	25,00%
B (A3)	2	12,50%
C (A4)	6	37,50%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

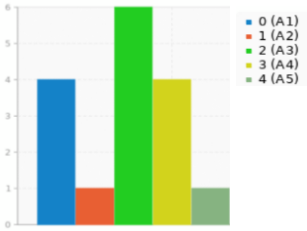
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	5	31,25%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	5	31,25%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	2	12,50%
AI - Artificial Intelligence (SQ007)	6	37,50%
CLOUD (SQ009)	4	25,00%
AditM - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	2	12,50%
None of above (SQ013)	4	25,00%



Control of nonconforming outputs

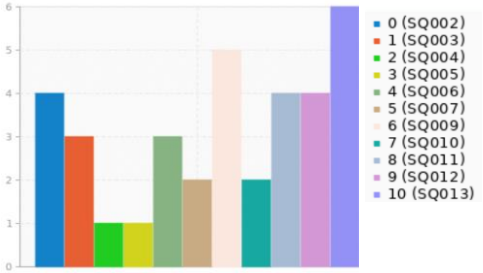
Q33 Does the organization use a certain level of implementation of I4.0 elements/pillars when managing non-conforming deliverables (e.g. when repairing, segregating, informing the customer, or obtaining approval to accept an exception, or documented information describing the nonconformity)?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	4	25,00%
A (A2)	1	6,25%
B (A3)	6	37,50%
C (A4)	4	25,00%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/Augmented reality (SQ003)	3	18,75%
HVInteg - Horizontal/Vertical Integration (SQ004)	1	6,25%
IoT - Internet of Things (SQ005)	1	6,25%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	5	31,25%
AditM - Additive Manufacturing (SQ010)	2	12,50%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	4	25,00%
None of above (SQ013)	6	37,50%



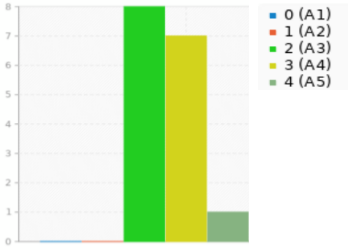
2.5. Questions related to the CHECK

Monitoring, measurement, analysis and evaluation

Q34 Does the organization use a certain level of implementation of I4.0 elements/pillars in monitoring, measuring, and evaluating QMS performance and effectiveness - e. g. automated monitoring, measuring and evaluation?

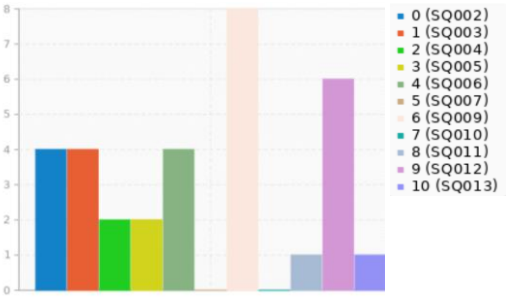
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	0	0,00%
A (A2)	0	0,00%
B (A3)	8	50,00%
C (A4)	7	43,75%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

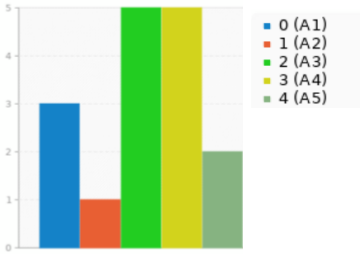
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	4	25,00%
SIMUL - Simulation/Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	2	12,50%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Intelligence (SQ007)	0	0,00%
CLOUD (SQ009)	8	50,00%
AditM - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	1	6,25%
BIGD - Big Data Analytics (SQ012)	6	37,50%
None of above (SQ013)	1	6,25%



Customer Satisfaction

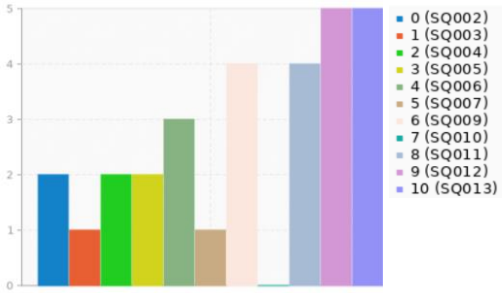
Q35 Does the organization use a certain level of implementation of I4.0 elements/pillars in monitoring and evaluating customer satisfaction?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	1	6,25%
B (A3)	5	31,25%
C (A4)	5	31,25%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

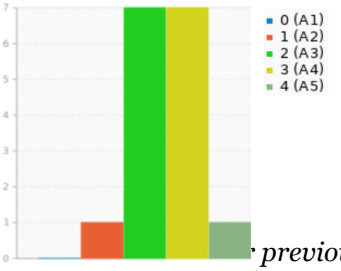
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	2	12,50%
SIMUL - Simulation/ Augmented reality (SQ003)	1	6,25%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - Internet of Things (SQ005)	2	12,50%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	1	6,25%
CLOUD (SQ009)	4	25,00%
AditM - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	4	25,00%
BIGD - Big Data Analytics (SQ012)	5	31,25%
None of above (SQ013)	5	31,25%



Analysis and evaluation

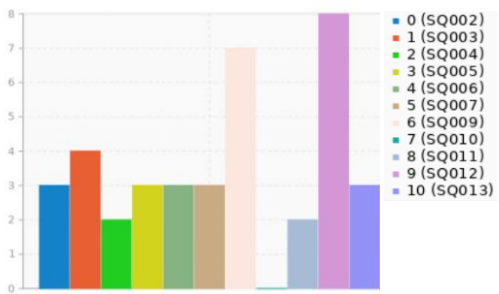
Q36 Does the organization use a certain level of implementation of I4.0 elements/pillars when analyzing and evaluating data and information from monitoring and measuring?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	0	0,00%
A (A2)	1	6,25%
B (A3)	7	43,75%
C (A4)	7	43,75%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 i previous question.

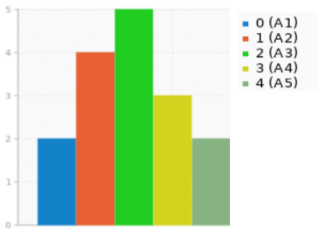
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/ Augmented reality (SQ003)	4	25,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	3	18,75%
CLOUD (SQ009)	7	43,75%
AditM - - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	8	50,00%
None of above (SQ013)	3	18,75%



Internal Audit

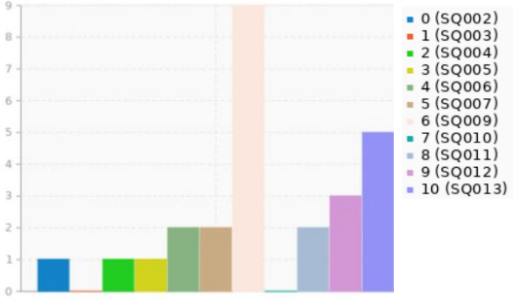
Q37 Does the organization use a certain level of implementation of I4.0 elements/pillars when planning, conducting, and evaluating internal audits?
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	4	25,00%
B (A3)	5	31,25%
C (A4)	3	18,75%
D (A5)	2	12,50%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

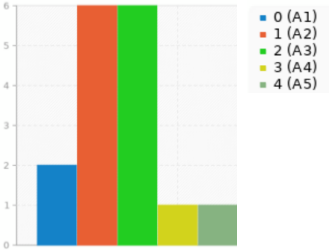
Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	1	6,25%
SIMUL - Simulation/ Augmented reality (SQ003)	0	0,00%
HVInteg - Horizontal/Vertical Integration (SQ004)	1	6,25%
IoT - Internet of Things (SQ005)	1	6,25%
CYBS - Cybersecurity (SQ006)	2	12,50%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	9	56,25%
AditM - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	3	18,75%
None of above (SQ013)	5	31,25%



Management Review

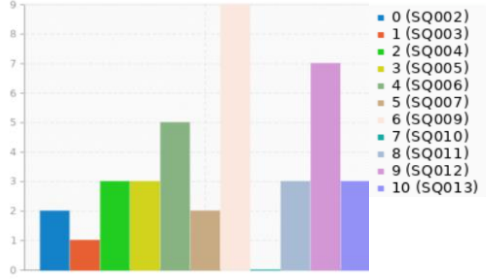
Q38 Does the organization use a certain level of implementation of I4.0 elements/pillars in management reviews (as well as required inputs and outputs)? (Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	6	37,50%
B (A3)	6	37,50%
C (A4)	1	6,25%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	2	12,50%
SIMUL - Simulation/ Augmented reality (SQ003)	1	6,25%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	5	31,25%
AI - Artificial Intelligence (SQ007)	2	12,50%
CLOUD (SQ009)	9	56,25%
AditM - Additive Manufacturing (SQ010)	0	0,00%
SupCH - Supply Chain / Block Chain (SQ011)	3	18,75%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	3	18,75%



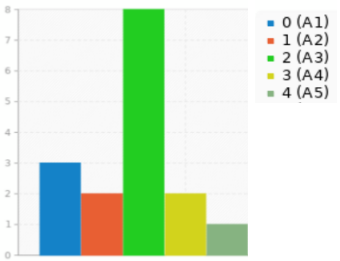
2.6. Questions related to the ACT

Nonconformity and corrective action

Q39 Does the organization use a certain level of implementation of I4.0 elements/pillars when assessing, reviewing non-conformities as well as taking corrective actions and evaluating their effectiveness?

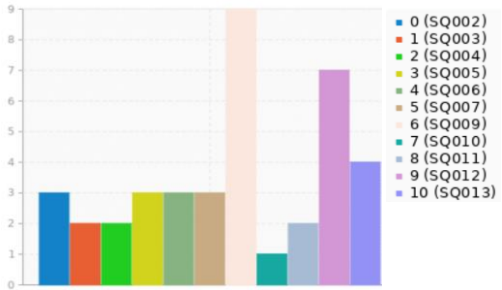
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	3	18,75%
A (A2)	2	12,50%
B (A3)	8	50,00%
C (A4)	2	12,50%
D (A5)	1	6,25%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	3	18,75%
SIMUL - Simulation/ Augmented reality (SQ003)	2	12,50%
HVInteg - Horizontal/Vertical Integration (SQ004)	2	12,50%
IoT - - Internet of Things (SQ005)	3	18,75%
CYBS - Cybersecurity (SQ006)	3	18,75%
AI - Artificial Intelligence (SQ007)	3	18,75%
CLOUD (SQ009)	9	56,25%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	4	25,00%

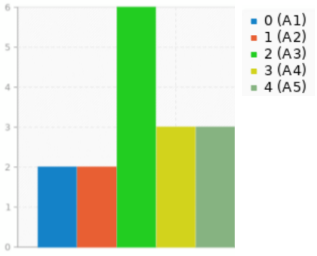


Continual Improvement

Q40 Does the organization use a certain level of implementation of I4.0 elements/pillars when implementing continuous improvement?

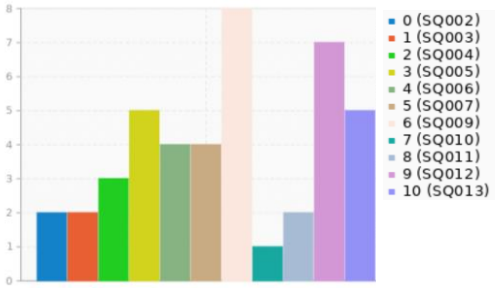
(Please, select from alternatives 0/A/B/C/D)

Answer	Count	Percentage
0 (A1)	2	12,50%
A (A2)	2	12,50%
B (A3)	6	37,50%
C (A4)	3	18,75%
D (A5)	3	18,75%



SQ: Cross the elements (pillars) of I4.0 that are most used for previous question.

Answer	Count	Percentage
ROBOT - Autonomous Robot (SQ002)	2	12,50%
SIMUL- Simulation/ Augmented reality (SQ003)	2	12,50%
HVInteg - Horizontal/Vertical Integration (SQ004)	3	18,75%
IoT - Internet of Things (SQ005)	5	31,25%
CYBS - Cybersecurity (SQ006)	4	25,00%
AI - Artificial Intelligence (SQ007)	4	25,00%
CLOUD (SQ009)	8	50,00%
AditM - Additive Manufacturing (SQ010)	1	6,25%
SupCH - Supply Chain / Block Chain (SQ011)	2	12,50%
BIGD - Big Data Analytics (SQ012)	7	43,75%
None of above (SQ013)	5	31,25%



Chapter 3. Competence needs in the enterprises

The overall evaluation of the results of the questionnaire can be summarized as follows:

- More than 63% of the 24 participating companies, operate in the automotive industry,
- 56% of enterprises employ more than 1,000 people,
- these companies currently mainly use CLOUDs, AI and CYBSS - Cyber security systems (more than 62%),
- more than 50% of companies implement in fulfillment of requirements of Sustainability (CSR), especially CLOUD but not completely and CYBS (44%).

The evaluation of the individual questions in 24 organizations brought the following significant findings.

3.1. Results related to the PLAN

In requirements of quality planning, i. e. in understanding of organization context and interested parties' expectations, determination of scope and processes of quality management, 60% of organizations has already implemented some of the I4.0 elements, however not completely (level C). The rest pf 40% of organizations either plan or is in the process of I4.0 elements implementation (A/B). Cloud Systems (CLOUD), Cybersecurity (CYBS) and Big Data Analytics (BIGD) have the most significant representation in terms of their usage. In understanding of needs of interested parties and determination of the necessary processes for quality management the implementation of Artificial Intelligence (AI) appears in roughly 30%.

The use of I4.0 elements in implementation of Quality 4.0 by management, policy development and customer focus are assessed as implemented but not completely (C) by 34% of the respondents. 31% of organizations responded that the implementation is in progress and in about 31% of cases is the implementation of these elements planned (A). In these areas of quality management, Cloud Systems (CLOUD) and Cybersecurity (CYBS) are preferred according to the results. Big Data Analytics (BIGD) is significantly manifested only in the process of understanding customer requirements.

Planning of quality management systems requires risks and opportunities analysis and determination of appropriate actions to manage them as well as quality goals setting and processes for achieving them. Here the elements of I4.0 are implemented but not completely (level C) in the case of 29% of organizations and other organizations either are in the phase of their implementation or plan to implement them (A/B). Cloud systems (CLOUD) are highly represented, but it is interesting that the respondents strongly prefer Big Data Analytics (BIGD) as a support for the effective functioning of quality management (Q17).

For assurance of resources, competence of people, their awareness, communication, documented information control, the respondents prefer in particular Cloud systems (CLOUD) and Cybersecurity (CYBS), but in the case infrastructure assurance Big Data Analytics (BIGD) (up to more than 50% compared to other I4.0 elements). Negatively was evaluated the use of I4.0 elements in the case of determining the necessary persons for the effective implementation of Q4.0, where up to 43.75% of the respondents assessed that they do not plan to apply any of the I4.0 elements in this area (Q18), however in the case of application, the Autonomous Robots (RO-BOT) reached high value, up to 25%, as well as in the case of infrastructure requirements (Q19) up to 37.5%.

In the case of determination and ensuring competences (Q23), it turned out similarly, where 37.5% of the respondents responded negatively to the implementation of I4.0 elements (level O). In verification of the conformity of product and service requirements – measurement and monitoring (Q21), external and internal communication (Q24) and management of documented information (Q25), the respondents assessed their state as there are at the level C - I4.0 elements are implemented but not completely. The high representation of CLOUD elements, in the case of environment, monitoring and measurement and communication (Q20, Q21, Q24), is surprising.

3.2. Results related to the DO

Regarding the I4.0 elements in Operation (its planning and management, design and development of products and services, their external provision, change management), except traditional representation of Cloud systems (CLOUD) and Cybersecurity (CYBS) also Simulation/Augmented reality (SIMUL) appeared to be significant element (Q28) and in the case of product and service provision (Q30) the Horizontal/vertical Integration (HVInteg) and Supply Chain/BlockChain (SupCH). In managing externally provided processes, products and services Additive Manufacturing

(AditM) (Q29) was represented also as significant and in releasing products and services the Autonomous Robots (ROBOT) (Q32).

On average, 37% of the respondents assessed the level of I4.0 implementation as not complete (C). In the case of the management of outsourced processes, products and services (Q29), up to 25% of the respondents answered that they did not plan to implement these elements, but 25% of the respondents are in the process of I4.0 elements implementation planning according to received data.

3.3. Results related to the CHECK

In performance evaluation, the respondents emphasized the use of cloud systems (CLOUD) and Big Data Analytics (BIGD). In analyzing and evaluating data from monitoring and measurement, BIGD reached a significant share of 50% compared to other I4.0 elements (Q36).

The most significant fact at this stage is that up to 40% of the respondents currently implement these elements in their quality management systems (B).

3.4. Results related to the ACT

Improvement of quality management systems requires application of tools that enhance customer satisfaction and it also requires investments in effective actions to decrease nonconformities of products and services. It is an interesting fact that, apparently in connection with the ongoing processes of I4.0 implementation, Cloud systems (CLOUD) (more than 50%) and Big Data Analytics (BIGD) (more than 40%) prevailed in the improvement phase at respondent organizations from all the I4.0 elements. In continuous improvement (Q40), the Internet of Thing (IoT) is also emerged as an important I4.0 element.

The fact that implementation of I4.0 is taking place in the majority of respondent organizations is also confirmed by the prevailing percentage (on average more than 40%) of the level B.

Conclusions

In introducing Q4.0 strategy the organizations mostly implement CLOUD systems and Big Data Analytics. Within the planning phase (PLAN), CLOUD, BIGD and CYBS are most applied in Quality Management; within the Operation (DO), especially CLOUD is the most applied followed by BIGD, CYBS and SupCH/Blockchain; in Performance evaluation (CHECK) again COUD and BIGD; and in the Improvement (ACT) significantly CLOUD and BIDG are applied and IoT also appeared (see Table 1).

Table 1. The results of the questionnaire in the PDCA structure

Answer	BASE	PLAN	DO	CHECK	ACT	TOTAL
ROBOT - Autonomous Robot	39,58%	23,01%	21,88%	15,00%	12,50%	22,39%
SIMUL - Simulation/ Augmented reality	33,33%	18,18%	21,09%	9,38%	12,50%	18,90%
HVInteg - Horizontal/vertical Integration	25,00%	19,32%	21,09%	12,50%	18,75%	19,33%
IoT - Internet of Things	41,67%	22,44%	17,97%	14,06%	31,25%	25,48%
CYBS - Cybersecurity	47,92%	30,11%	26,56%	20,31%	25,00%	29,98%
AI - Artificial Intelligence	45,83%	21,59%	12,50%	12,50%	25,00%	23,48%
CLOUD – Coud systems	58,33%	38,35%	32,03%	45,31%	50,00%	44,80%
AditM - Additive Manufacturing	22,92%	10,23%	11,72%	0,00%	6,25%	10,22%
SupCH - Supply Chain/Blockchain	27,08%	19,03%	26,56%	17,19%	12,50%	20,47%
BIGD - Big Data Analytics	33,33%	31,82%	27,34%	35,94%	43,75%	35,50%
None of above	16,67%	29,26%	28,13%	25,00%	31,25%	25,86%

The summary of the research points out the CLOUD as the most applied in Quality Management compared to other I4.0 elements, in all stages of PDCA. Cybersecurity is an important part in the planning phase (PLAN), and Big Data Analytics (BIGD) is important in the Improvement (ACT). But also, for organizations Internet of Things (IoT), Arifical Intelligence (AI), Autonomous Robot (ROBOT) and Supply Chain/Blockchaim (SupCH) are very important.

The framework of education and the acquisition of skills for the support of competences in companies and universities should focus on these areas.

The least applied tools in Quality Management in the respondent organizations are Additive Manufacturing (AditM), Simulation / Augmented reality (SIMUL) and Horizontal / Vertical integration (HVInteg).

According to the research results, only 11% (on average) of the respondents confirmed the full implementation of I4.0 elements in analyzed management systems fields (level D).

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