PERSIST.

White paper for IO3:

Conducting Delphi Studies on future PSM roles and competencies in the era of Industry 4.0

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1. Introduction: Conducting Delphi Studies on future PSM roles and competencies in the era of Industry 4.0

1.1. Building on the outcomes of IO1 and IO2 a Delphi study with 45 professionals has been conducted to identify future PSM roles and competencies

This report addresses the third intellectual output (IO3) of the PERSIST Erasmus+ project. Previous IOs included a systematic literature review on Industry 4.0 skills and competencies within purchasing and supply management (PSM) and multiple explorative World Café studies addressing future roles and skills within PSM in the era of Industry 4.0. In IO3 the results of the Word Cafés and expert interviews of the IO2, which were carried out based on the results from IO1, will be deepened with the methodology of the Delphi study. Based on the Delphi study, future roles and skills within purchasing will be developed. Thus, the results of the IO3 are scientifically derived assumptions and future trends on how PSM will change in the future in the era of Industry 4.0.

To prepare the Delphi study, the results of the IO2 are carefully evaluated and aggregated into questions or statements, which are applied and discussed in the Delphi Studies. Within the Delphi study context, these statements are called projections. The output of the IO3 is a future-oriented view of the emerging roles and required skills for professionals in PSM. Here the Delphi study allows a qualitative and quantitative assessment of the roles and projects by the Delphi experts. Qualitative assessments are performed on the basis of text comments which are evaluated by the researchers. For the quantitative assessment, all participants were asked to rate the projections within the Delphi survey according to the expected probability of occurrence, the impact on the industry, the desirability of occurrence, and the level of adoption within the industry in a time frame from now, 5 years, 15 years, and 25 years.

The Delphi study results suggest six future roles and nine future skills within purchasing in the era of Industry 4.0. These future skills need to be educated within future study programs which will be addressed within IO4 of the PERSIST Erasmus+ project. Within IO4, the Delphi study results will be used to produce gamification elements and playful interaction concepts to educate future purchasing professionals. Higher education can use these gamified elements to train the Industry 4.0 skills within study programs and allow students to prepare for future professional tasks. Within the last intellectual output of this project, IO5, the gamified learning elements developed in IO4 are realised and validated within a module-based course.

1.2. Research objective of the Delphi study

Today's purchasing professionals, who are specialists in their tasks, are able to boost companies' competitiveness and performance (Bals, Schulze, Kelly, & Stek, 2019; Barnes & Liao, 2012; Nair, Jayaram, & Das, 2015). The purchasers' task-specific specialization arose from an increasing maturity level within purchasing, where highly mature organizations define specific professional roles and mandates according to business practices. Further, each professional role consists of specific skill sets, allowing the professionals to fulfil their tasks (L. Knight, Y.-H. Tu, & J. Preston, 2014; Pekkanen, Niemi, Puolakka, Pirttilä, & Huiskonen, 2020). These professional roles also referred to as profiles or job descriptions, are defined according to the firm's functional purchasing strategy, the firm's business environment, and firm-specific characteristics, including its product categories, and purchasing portfolio. Examples of these professional roles in purchasing include the distinction between the chief purchasing officer, the purchasing engineer, and the purchaser of indirect or direct materials (Schiele, 2019). However, these professional roles are not a stable phenomenon. These roles change over time, according to changes within the firm's strategy or business environment.

One crucial change in firms' business environment is the introduction of new technologies that can be used in business. Today, the fourth industrial revolution, Industry 4.0, has a significant influence on purchasing organization and practice (Glas & Kleemann, 2016; Kagermann, 2015; Liao, Deschamps, Loures, & Ramos, 2017). Besides the technological changes in Industry 4.0, PSM also must face increasing globalization and attention to corporate social responsibility. Here firms need PSM professionals to manage the higher dynamic and increasingly complex environment. This paper continuous with developing purchasing maturity by refining professional roles in purchasing, taking a future perspective on purchasing professional roles and skills. For the following parts of the paper, 'skills' are viewed as abilities learned by practice or knowledge acquisition (Carr & Smeltzer, 2000; Eltantawy, Giunipero, & Fox, 2009).

1.3. Research Questions

Previous scholars addressed future skills in purchasing, e.g., the work of Bals et al. (2019), and professional roles or profiles, e.g., the work of Faes, Knight, and Matthyssens (2001) or Mulder, Wesselink, and Bruijstens (2005), but are outdated or miss a detailed description of these skills. Therefore, the following three research questions will be addressed:

(1): What new professional roles in purchasing and supply management exist within an Industry 4.0 context?

(2): What are the future Industry 4.0 skills within operational purchasing and supply management?

A Delphi study was used to answer the research questions above. Based on the used methodology, a total of seven professional roles, nine skills have been identified. Further, the Delphi study participants assessed the identified professional roles and skills based on the expected probability of occurrence, the impact on the industry, the desirability of occurrence, and the level of adoption within the industry. For assessing the level of adoption within the industry, a 50% threshold level was set, which was evaluated within a timeframe from today, 5 years, 15 years, and 25 years. The presented results support the fact that professional roles and skills within purchasing and supply management are not stable but change due to environmental changes in the organization's surroundings. One significant influence, which is also core to this research, is the impact of technological developments on the profession of purchasing and supply management. This research provides a guideline for future work and practitioners to organize human resource management within the future, Industry 4.0, purchasing. Also, future research should address how these Industry 4.0 professional roles and skills can be educated. Here, a focus for both groups, students currently developing the fundamental purchasing skills and professionals already working within the field, need to be considered. Within the PSM field, appropriate study programs and training need to be developed to allow a continuous learning approach within the field.

1.4. Structure of the white paper

After the introduction, this paper discusses a changing purchasing environment's theoretical background and the necessary purchasing skills. Next, the Delphi method is described as the means to acquire empirical insights. The outcome of the employed methodology is presented in the results section, and its implications are discussed from a theoretical and managerial perspective.

2. Theoretical background: Using professional roles and skills as useful instruments for change towards Industry 4.0 in purchasing and supply management

The theoretical foundation of this research is based on three pillars. First, an understanding of the Concept Industry 4.0 and its influence on purchasing and supply management is needed. Since the paper focuses on a bottom-up approach to identify the influence of technological developments on purchasing, the technological developments provide an understanding of how organizations and professionals within the field are influence. Here new tasks and positions within the firms are emerging, requiring specialized employees to fulfil the tasks. Following this assumption, new professional roles within purchasing will be introduced, representing the second part of the addressed theoretical background. Next, a detailed understating of skills within purchasing and supply management is needed since each employee's roles are linked to a specific set of skills. For this reason, the third part of the theoretical background focuses on future, Industry 4.0, skills in purchasing.

2.1. Industry 4.0 in purchasing and supply management

Scholars have identified various technologies that form a new industry paradigm. Examples of emerging technologies are 3D-printing, digital twins, cyber-physical systems, blockchain technology, big data analytics, and artificial intelligence (Kouhizadeh, Saberi, & Sarkis, 2020; Raguseo, Vitari, & Pigni, 2020; Schiele & Torn, 2020). At the current stage of research, scholars analyse these developing technologies' impact on businesses, society, and people. Within business research, a significant influence on the value chain, e.g., purchasing, productions, and sales, is expected.

However, an accepted definition of the future industry scenario does not exist yet (Brettel, Friederichsen, Keller, & Rosenberg, 2014), making it difficult to make sound arguments on how each field's impact can be evaluated precisely. For further parts of this paper, the future industry paradigm's definition will follow the so-called Industry 4.0 definition of Schiele and Torn (2020). Schiele and Torn (2020, p. 6) define Industry 4.0 as: "Industry 4.0 is characterized by cyber-physical systems with autonomous machine-to-machine communication." Within the scope of this research, the impact of Industry 4.0 on PSM is further analysed. Here, the assumption is followed that recently introduced and maturing technologies will influence the field on an operational and strategic level.

First, one of the older technologies introduced is the sensors and actuators, which enable a direct identification of demand within the warehouse. However, within the Industry 4.0 scenario, these

technologies are used to connect the physical and digital world. Here, cyber-physical systems are formed based on existing sensor technologies and software (Monostori, 2014). As a result of the connection between the physical and digital world, no human intervention is needed to identify demands.

Second, e-procurement and e-sourcing systems are developed to support various tasks of purchasing professionals. Here e-procurement systems have a significant influence on the operational ordering of goods and services from suppliers. The need for human interaction is reduced by sophisticated technology support, where for example, the operational ordering of products or payment processes are managed by the system (Hawking, Stein, Wyld, & Foster, 2004).

Thus, less human interaction is included within the operational purchasing task, allowing to shift employees to more strategic tasks, e.g., supplier identification, risk management, or innovation sourcing. Advanced software systems within the sourcing process, also known as e-sourcing solutions, allow for analysis of past requests for quotation, which help improve the preparation process of future quotations and extract an extensive list of suppliers (Schiele & Torn, 2020). In its advanced form, these preparation and planning processes are supported by artificial intelligence, where also algorithms allow advanced forecasting (Bohanec, Kljajić Borštnar, & Robnik-Šikonja, 2017; Dubey et al., 2020).

Thus, artificial technology is the third technology introduced to support purchasing tasks. However, the step towards artificial intelligence within purchasing is not made yet. At the current stage, especially the work within operational purchasing can be reduced, where demand forecasting can be improved based on big data analytics (Hofmann, Neukart, & Bäck, 2017), which is the first step towards the introduction of artificial intelligence within purchasing. Further, artificial intelligence does not only allow to analyse purchasing data, e.g., past contracts and quotations, here the technology can also be used with sophisticated text mining, data analytics, and interactive communication bots to support identification and selection of suppliers (Schiele & Torn, 2020).

Fourth, the implementation of blockchain technology within purchasing impacts the professional purchasing task significantly. Here, blockchain technology can be used to create a truly transparent supply chain (Kouhizadeh et al., 2020; Tapscott & Tapscott, 2017). In this context, blockchain technology provides a secure infrastructure for the distribution of immutable information. It allows a recording of the unchangeable history of transactions, reducing information asymmetries, and making the technology useful to facilitate payment processes within the supply chain (Babich & Hilary, 2020; Treiblmaier, 2018). Further, blockchain technology allows the implementation of smart contracts, which potentially substitutes many operational activities within purchasing (Chang, Chen, & Lu, 2019).

In summary, based on technological developments, a paradigm shift in the industry is observed, which is also influencing PSM in the sense of Industry 4.0. The paradigm shift impacts PSM significantly, reducing the number of employees working in operational tasks and shifting the focus on strategic purchasing. Due to this shift, the professional roles in the purchasing organization change, and an adopted skill set is required. The following two sections focus on these roles and skills in purchasing.

2.2. Professional roles in purchasing and supply management

The work of Jones (2013) uses professional roles as a concept within organizational structures. Here, professional roles are defined based on job descriptions, the organization's function, professional roles, and specific skills that belong to these roles (for illustration, see: Figure 1).

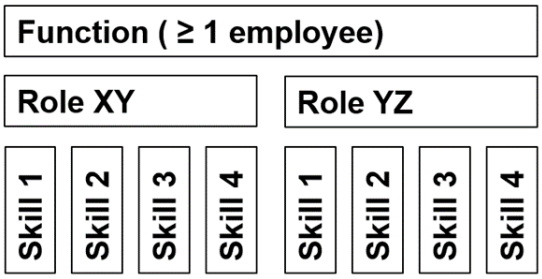

Figure 1 - Illustrating the concept of roles and skills within an organization (Jones, 2013)

Within PSM, various terms for these roles exist, e.g., roles and responsibilities (Johnson, Leenders, & Fearon, 1998), profiles of buyers (Faes et al., 2001), job profiles (Mulder et al., 2005), and purchasing roles (Schiele, 2019). Thus, a range of different jobs exists within purchasing, including purchasing manager, buyer, assistant buyer, and senior buyer (Mulder et al., 2005). Besides, various professional profiles can be identified, relating to the tasks the purchasing professional is called on to perform. Here, Mulder et al. (2005) distinguish between information and communication, management, initial purchasing, and practical purchasing. In this context, the work of L. Knight, Y. H. Tu, and J. Preston (2014) explores the link between purchasing type and purchasing skill, identifying 33 skills for the responsibility of buying strategic, tactical, and routine products. Further, the work of (Faes et al., 2001) describes five profiles of effective buyers based on cluster analysis, including the go-getter, classic negotiator, caretaker, traditional buyer, and technical experts.

Nevertheless, Schiele's (2019) work offers a categorization of seven role models, which best suits this paper's research interest. These seven roles include the distinction between direct and indirect material purchasing: (1) operational procurement, (2) purchaser of direct materials/serial purchaser, (3) purchaser of indirect materials, (4) public procurement, (5) purchasing engineer, (6) chief

purchasing officer (CPO), and (7) other specialized roles such as purchasing controller, supply risk manager, and purchasing human resources agent (Schiele, 2019). Based on the work of Schiele (2019) a description of these roles is provided in Table 1. However, unlike the work of Faes et al. (2001), Schiele (2019) does not provide a list of the most important traits or skills for these roles. Following the organisational structure logic, these professional roles and skills are directly linked (Jones, 2013). Therefore, the following section focuses on previous literature within the field of PSM on professional skills and competencies.

Table 1 - Role models in purchasing based on Schiele (2019)

Name of the role	Description
Operative procurement	• Is responsible for operational activities, i.e., ordering material and expediting the order • In manufacturing firms, the most common cross-functional interface partners are in production and (inbound) logistics.
Purchaser for direct materials/serial purchaser	• This is the most common role in a manufacturing firm. • The serial purchaser is responsible for sourcing direct materials for production, developing a sourcing strategy and selecting and contracting suppliers.
Purchaser for indirect materials	• This person is responsible for sourcing indirect materials, developing a sourcing strategy and selecting and contracting suppliers. • Several variants - each with different skills requirements and different cross-functional interface partners in the firm - can be distinguished, for instance, service purchaser, investment purchaser and MRO purchaser (maintenance, repair, and overhaul)
Public procurement	• Most of the purchasing activities in the public and the private sector overlap. • However, concerning the legal framework in particular on contracting issues, substantial differences exist, which result in a specialised job profile for public procurement.
Purchasing engineer	• The procurement or purchasing engineer - sometimes also called advanced sourcer - joins a new product development team as a permanent team member • The purchasing engineer's main interface partner in the firm is the research and development (R&D) function.
Chief purchasing officer (CPO)	• Organises the purchasing department and gives leadership to the purchasers, representing the purchasing function in the board of directors of the firm.
Other roles	• **purchasing controller** (evaluates purchasing and supplier performance, monitors strategy execution), • **supply risk manager** (operates the preventive risk assessment in the supply chain and manages the reactive risk mitigation) • **purchasing HR agent** (recruits purchasers and supports their skills development) • **systems and strategy** (implements and update purchasing IT systems as well as purchasing processes, organises strategy development) • **supplier development engineer** (detached to support suppliers to improve their services), • **supply chain finance** (supports suppliers with favourable financing conditions) • **sourcing market analyst** (conducts market analyses and identifies new suppliers), • **innovation purchaser** (systematically searches for supplier innovations)

2.3. Previous literature on future skills in purchasing

In past years, the purchasing profession developed into a strategic function, utilizing company resources to increase firm performance (P. D. Cousins, L. Giunipero, R. B. Handfield, & R. Eltantawy, 2006; Kauffman, 2002; Tassabehji & Moorhouse, 2008) and has evolved into a human-centric direction, meaning that the human capital input is of strategic importance to firms (Bals et al., 2019; Hohenstein, Feisel, & Hartmann, 2014). Due to the importance of the human aspect, the contributions of PSM to a firm's effectiveness are considered to be mostly dependent on individual PSM professionals' *'skills'* (Feisel, Hartmann, & Giunipero, 2011; Giunipero & Pearcy, 2000; Louise Knight et al., 2014; Tassabehji & Moorhouse, 2008).

The PSM skills literature is tributary to Larry Giunipero and co-authors' seminal work. The scientific reports for the longitudinal research of the *Center of Advanced Purchasing Studies* in 1993 and 2000 (Giunipero, 2000a; Kolchin & Giunipero, 1993) resulted in the study of Giunipero and Pearcy (2000) that wraps-up the findings in the field in the 20th century providing a PSM skills taxonomy that is displayed in Table 2.

Table 2 - Skills required of a world-class purchaser, adapted from Giunipero and Pearcy (2000, p. 11)

SKILLS REQUIRED OF A WORLD-CLASS PURCHASER (DERIVED FACTORS)			
Strategic Skills	**Process Management Skills**	**Team Skills**	**Decision-making Skills**
Strategic thinking	Organisation/time management	Teamwork	Computer literacy
Supply base research	Tactfulness in dealing with others	Leadership	Ability to make decisions
Structuring supplier relationships	Written communication	Managing change	
Technology planning	Problem-solving	Managing internal customers	
Supplier cost targeting	Conflict resolution	Salesmanship	
Behavioural Skills	**Negotiation Skills**	**Quantitative Skills**	
Interpersonal communication	Negotiation	Computational	
Risk-taking/entrepreneurship	Customer focus	Technical	
Creativity	Influencing and persuasion	Blueprint reading	
Inquisitiveness	Understanding business conditions	Specification development	

Adding to this taxonomy, Giunipero, Denslow, and Eltantawy (2005, p. 609) described the overlap between PSM skills and entrepreneurial skills, which are presented as *"flexibility skills" ("planning, influencing, internal motivation, creativity, risk management, decision-making, interpersonal communication"*). In 2006 it was expected that the buyer's traditional operational role would "rapidly disappear" and that purchasers soon will be assigned to strategic roles (P. D. Cousins, L. C. Giunipero, R. B. Handfield, & R. Eltantawy, 2006, p. 835). The strategic competencies for future supply managers (as proclaimed in 2006) are team-building skills (*"leadership, decision-making, influencing, and compromising"*), strategic planning skills (*"project scoping, goal-setting, and execution"*), communication skills (*"presentation, public speaking, listening and writing"*), technical skills (*"web-*

enabled research and sourcing analysis") and broader financial skills (*"cost accounting and making the business case"*) (Paul D Cousins et al., 2006, p. 836). According to Giunipero et al. (2005), the purchaser increasingly needs entrepreneurial skills within the growing importance of incorporating PSM into cross-functional teams.

The research of Tassabehji and Moorhouse (2008) conclude that a purchaser needs to master a full set of skills consisting of:

- Technical Skills (*"product knowledge, computer literacy, total quality management, and government legislation and advanced procurement process skills"*),
- Interpersonal Skills (*"written and oral communication, conflict resolution, influencing and persuasion, group dynamics, leadership, problem solving and interpersonal and cultural awareness"*),
- Internal Enterprise Skills (*"effectively conduct market analysis, manage internal relationships, global sourcing evaluation, internal change management and planning, and organisational skills"*),
- External Enterprise Skills (*"management of external relationships, and stakeholder change management"*) and
- Strategic Business Skills ("*planning and managing strategic partnerships and alliances, risk management, and adding value to the organisation"*) (Tassabehji & Moorhouse, 2008, p. 59).

For the increasingly strategic role for PSM, Tassabehji and Moorhouse (2008) recommend a "new categorisation of skill types required for procurement", *"with an increasing emphasis on skills that can be seen as more generic and management-oriented, applied in a procurement context"* (Tassabehji & Moorhouse, 2008, pp. 59-60). They reckon that the volume of PSM skills compared to general management skills had lessened *"over time as business environments become more dynamic, requiring different skills".* These general management skills are *"applicable to other organisational functions"*, as is recently confirmed by Bals et al. (2019) in their replication of Tassabehji and Moorhouse's (2008) study in which they added 17 skills to the original framework (see: Table 3). Bals et al. (2019):

> *"The combination of the newly identified competencies with others that have already been found in previous research (…), suggests that a new, more modern competency profile for PSM practitioners is needed, that reflects a business context influenced by the latest developments in industry 4.0 and sustainability, such as moving towards a circular economy and circular supply chains"* (Bals et al., 2019, p. 10).

Table 3 - Competences matching with Tassabehji & Moorhouse (2008) and additional competences gathered in interviews (adapted from Bals et al., 2019, p. 7)

Technical Skills	Interpersonal Skills	Internal/ External Enterprise Skills	Strategic Business Skills
Matching competences – competences identified by Tassabehji and Moorhouse (2008) ***and found in the interviews***			
basic knowledge on PSM role & processes; computer literacy; contract management; cost savings; eProcurement technology; intellectual property; KPI reporting design; languages; negotiation; process optimisation; product knowledge; project management; quality assurance; strategic sourcing; tools and Systems; implementation	analytical skills; conflict resolution; creativity; decision making; effective questioning techniques; integrity; interpersonal communication; knowledge sharing; leadership; learning agility; prioritisation; remote virtual working; results focus driving for results; structured way of working; teamwork-working in teams	change management; communication skills; cross-functional abilities & knowledge; cultural awareness; customer focus; engineering; finance; logistics; manufacturing & production; marketing; networking; quality (QHSE); R&D; supply chain; sales; stakeholder relationship management; supplier management;	business acumen; financial acumen; PSM best practice intelligence scouting; risk management; strategic thinking
Additional competences – competences <u>NOT</u> identified by Tassabehji and Moorhouse (2008) ***and found in the interviews***			
automation; big data analytics; innovation sourcing; innovative sourcing approaches	curiosity; deal with ambiguity; humility; mobility; openness, open-minded; passion; resilience; self-confidence; self-reflection; self-reliance		critical thinking; holistic supply chain thinking; sustainability

Bals et al. (2019) underline that the PSM function faces the Fourth Industrial Revolution's effects. Machine-to-machine communication will overtake operational tasks. Purchasers need to solve more complex problems, and therefore other competences will be required (Von der Gracht, Giunipero, & Schueller, 2016). Purchasers mainly needed cognition and professional skills. Future PSM professional will also be selected for personal skills, traits and behaviour. The competent purchaser masters knowledge, professional skills, interpersonal skills and intrapersonal traits (Bals et al., 2019; Von der Gracht et al., 2016).

As the next step towards Industry 4.0 skills in purchasing, a systematic literature review was performed. The Industry 4.0 PSM skills literature review focuses on identifying future procurement skills within Industry 4.0 oriented scientific literature. It starts with the creation of appropriate search syntax divide the search string into three segments: 1) Procurement segment: include all synonyms

and keywords connected with procurement, such as PSM, supply chain, etcetera; 2) Industry 4.0 segment: include all synonyms and keywords connected with Industry 4.0. such as industrial revolution, 4th, smart, IoT, IoE, digitization, digitisation, future, trends, big data, automation, robotization, robotization, artificial intelligence, autonomous; 3) Skills segment: include all synonyms and keywords connected with skills, such as Competencies, training, education. A total of 3617 articles were identified, and 50 articles were selected for in-depth review. The results were compared with a list of current PSM competencies and future PSM competencies defined in Bals et al. (2019) to analyze the impact of Industry 4.0 on skills in PSM (see Table 4). However, this literature review is not the center of this paper.

Table 4 - Comparison of Top 10 current PSM skills, Future PSM skills, and Industry oriented 4.0 PSM skills

Current PSM skills	**Future PSM skills**	**Industry 4.0 oriented PSM skills**
Analytical skills	Analytical Skills	Analytical skills
Strategic thinking	Strategic thinking	Strategic thinking
Basic knowledge of PSM roles & processes	Big Data Analytics	Big Data Analytics
Communication skills	Holistic supply chain thinking	Holistic supply chain thinking
Cross-functional abilities & knowledge	Automation	Cross-functional abilities & knowledge
Interpersonal Communication	Computer Literacy	Business Acumen
Negotiation	eProcurement Technology	Decision making
Stakeholder Relationship Management	Process optimization	Logistics
Strategic sourcing	Strategic Sourcing	Project Management
Sustainability	Sustainability	Teamwork-working in teams

The comparison shows some areas where Industry 4.0 PSM-oriented skills align with the more general current and future PSM skills. Analytical skills and Strategic thinking represent two types of skills where there is an alignment across the board. Big Data Analytics and Holistic Supply Chain thinking connect Industry 4.0 PSM oriented skills with Future PSM skills and Cross-functional abilities & knowledge match Current PSM skills with the Industry 4.0 oriented PSM skills. The outcome of this systematic literature review is used for the projection development for the later-described Delphi study.

3. Methodology: Internet-based real-time Delphi study

Within this research, a real-time Delphi study has been conducted. The method allows forecasting future professional roles and skills in purchasing and supply management based on previously developed projections, which are qualitatively and quantitatively evaluated by a group of experts (Kopyto, Lechler, Heiko, & Hartmann, 2020; Rikkonen & Tapio, 2009; Rowe & Wright, 1999). These projections have been developed base on a systematic literature review as a theoretical foundation and three explorative World-Cafés. The detailed projection development process is presented in the following and illustrated in Figure 2.

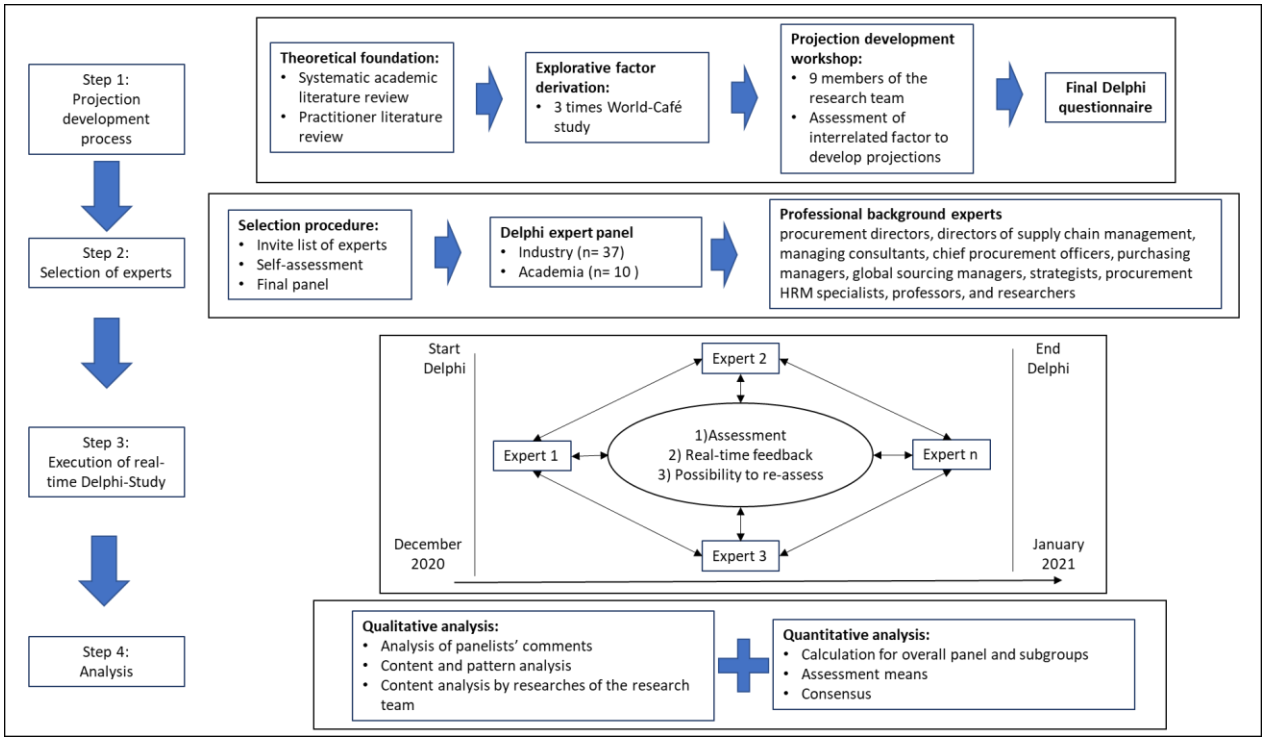

Figure 2 - Delphi study process

3.1. The real-time Delhi method

The Delphi method or Delphi technique is a structured communication technique or method, originally developed as a systematic, interactive forecasting method (Gnatzy, Warth, von der Gracht, & Darkow, 2011; Rowe, Wright, & Bolger, 1991). The method relies on a panel of experts and is suitable for long-term research objectives, where objectives include a high uncertainty, and only limited information is available (Gray & Hovav, 2008; Rowe et al., 1991). Here the method aims to source data from a specific set of experts, a structured group of individuals with expert knowledge within the field, where the assumption is that a structured group of individuals is more accurate than those from unstructured groups (Kopyto et al., 2020; Rikkonen & Tapio, 2009). The group of experts, experts of the conducted

Delphi study, is addressed in more detail within the next section. Each Delphi study is organized into several steps, which are followed in a systematic procedure.

First, future-oriented propositions, also called projections, are developed according to the research objectives (Rowe & Wright, 2001; von der Gracht, 2012). Next, the experts evaluate these projections based on numerical variables in the interest of the research objectives, such as the projection's impact or likelihood of occurrence (Kopyto et al., 2020). Here, experts can most often evaluate the projections based on quantitative measures and provide qualitative assessments with written justification. Afterward, the experts receive feedback about the group opinion from the Delphi facilitator and have the opportunity to reevaluate their initial answers based on the feedback they received (Rowe & Wright, 1999). The procedure of circling feedback and reevaluating answers may be repeated several times. Within the original Delphi procedure, the goal was to create consensus among the experts regarding the addressed propositions, this time the goal is to foster a reliable group opinion (Diamond et al., 2014; Landeta, 2006). Also, within the presented study, the research objective is to foster a reliable group opinion for the particular projections. There are various Delphi types but this research applies the real-time Delphi approach with the use of the Calubrum Sureveylet software.

All different types of Delhi studies build on four general principles: (1) anonymity; (2) iteration; (3) controlled feedback; and (4) statistical group response (Dalkey & Helmer, 1963; Kopyto et al., 2020; Rowe & Wright, 2001). The first principle, anonymity, allows mitigating negative group constraints, including the withholding of potentially unpopular responses and opinions. The second principle enables a multi-rounded discussion and the revision of prior assessments. Here, the third principle allows the Delphi facilitator to provide systematic feedback to the group in qualitative and quantitative form. Often used feedback methods include the return of numerical forms (such as tables) and graphical formate (such as boxplots). This feedback also includes tendency measures such as the mean, median, or majority of the assessment and a consensus measure during the single Delphi rounds (Kopyto et al., 2020). Following this procedure, Delphi studies show higher accuracy in forecasts than conventional surveys.

Nevertheless, the two most often used types of Delphi studies exist, the conventional "paper-and-pencil" type and the internet-based real-time Delphi approach (Gnatzy et al., 2011). Within this research, it was chosen to use the internet-based real-real time method. Here the research by proved that both approaches are comparable and lead to similar results, where the real-time approach is likely to have a positive effect on response rates and validity because of the functionalities of the software and its positive impact on the appearance, process, and reduced effort (e.g., time effort). To facilitate this Delphi study, the Calubrum Sureveylet software was used with the real-time setting. The software

allowed to stick to all four general Delphi principles, where participants have treaded anonymously, a real-time iteration was possible, controlled feedback could be provided via mail, and statistical group responses were presented within the projection assessment phase.

3.2. Developing the Delphi projections as the first step of the Delphi procedure

The basis for the projections within this Delphi study is a systematic literature review and three explorative World Cafés (see Figure 2) for the full projection development process). Here, the described development process allowed to develop a survey with questions and projections to enrich the Delphi study's value, validity, and reliability. It was chosen to continue the research after the three World Cafés, since the outcome of the World Cafés was explorative in nature and a small number of experts were present within each World Café.

Within the first step of projection development, relevant academic and practitioner literature was reviewed systematically to identify Industry 4.0 skills in purchasing and supply management. As described in the literature background above, 3617 articles were identified, and 50 articles were selected for in-depth review. The in-depth review yielded a list of current, future, and Industry 4.0 skills in purchasing and supply management. As a next step within the projection development phase, three World Café were organized. In order to compare the three World Cafés, 1) the first organized in Tallinn, 2) the second in Košice, and 3) the third in Dortmund, each World-Café was set up similarly and addressed the same three discussion questions. Each World Café started with a short introduction to the project and addressed the workshop's organizer's topic. Next, the group was split into three discussion tables, where each discussion round within the World-Café took 20 minutes, and after one round, there was five min break. The moderator introduced the discussed topic, provided a summary of the previously discussed results, and facilitated the participants' discussion. Further, the moderator wrote down responses on a shared whiteboard so that all participants could see them. After the three discussion rounds, all participants returned to the main lobby of the call, and the relevant moderator presented the results of the final whiteboard of each roundtable. Next, a systematic voting procedure was used, where each participant could distribute ten points per discussion table for the prominent outcomes of each question addressed. The voting procedure was managed within the online whiteboards, where participants could distribute stars for each discussion results according to its importance.

Based on the three World Cafés, an explorative list of future professional roles and skills in PSM has been extracted. Next, we followed the approach of Roßmann et al. (2018) and organized an internal

projection development workshop with three members of the research team. The workshop was conducted to cross-validate the shortlist of the previous step and to develop initial projections. This list was compared to the found professional roles and skills in literature, which resulted in 17 projections, eight future professional roles and nine future skills in purchasing and supply management (see Table 5). Moreover, since many projections may lead to a reduced response rate and increase the probability of a sparse completion of the questionnaires, the number of projections was limited to 17. This is in line with the proposition to limit the number of projections to a maximum of 20 (Kopyto et al., 2020).

Table 5 - Delphi study projections

Category	Description
ROLE 1	"The **Robotic Process Automation (RPA) Manager** works at the interface between purchasing and IT, responsible for implementing and operative running of RPA tasks within purchasing."
ROLE 2	"The **Data Analyst and Value Manager** in purchasing are responsible for purchasing data automation which is supported by blockchain technology, e.g., smart contract, and (big) data analytics."
ROLE 3	"The **Chief System Change Officer** in purchasing is responsible for balancing system automation with employee tasks by introducing and monitoring new purchasing systems and ensuring individuals have up-to-date knowledge."
ROLE 4	"The **Ramp-up Manager** in purchasing is responsible for setting up the digital interface between the buying firm and suppliers, involving the harmonization of data and effective stakeholder communication."
ROLE 5	"The **Data Maintenance Officer** in purchasing is responsible for ensuring data accuracy by checking the alignment between the physical and digital world and highlighting any changes in product, processes, and organization."
ROLE 6	"The **Chief Disruption Manager** in purchasing is responsible for the business continuity plan, solving any disruptions and ensuring that systems can still run in the event of technology or human failure."
ROLE 7	"The **Purchasing Innovation Scout** is responsible for identifying innovative purchasing approaches and new technologies or systems within purchasing, which will support key business drivers."
ROLE 8	"The **Digital Legislation Specialist** in purchasing is responsible for ensuring that purchasing processes comply with any relevant laws, regulations, and policies, including the implementation of public procurement requirements into the purchasing systems."
SKILL 1	"**Data Analytics skills** within purchasing include handling, analyzing, and interpreting large amounts of data by using data mining and visualization to identify and solve problems, which allows for understanding the potential and impact of decisions."
SKILL 2	"**Strategic Mindset skills** in purchasing include supply-based research by harnessing Industry 4.0 practices' benefits to meet overall organizational aims and objectives, thus recognizing the importance of engaging and communicating with suppliers in innovative ways."
SKILL 3	"**Holistic Supply Chain Management skills** in purchasing relate to a coherent and integrated understanding of the vertical and horizontal supply chain of goods and services, which allows management of the supply chain from economic and environmental perspectives."
SKILL 4	"**E-Procurement Technology skills** will be based on the growing functionality and scope of purchasing and supplier relationship management systems, these skills focus on working with these systems and define future system development requirements."
SKILL 5	"**Robotic Process Automation (RPA) skills** include implementing RPA in purchasing by configuring software bots to capture and interpret applications for processing a transaction, manipulating data, triggering responses, and communicating with other digital systems."
SKILL 6	"**Digital Contract Management and Legal skills** to implement legislative and other legal requirements into automated purchasing processes, utilizing blockchain technology and smart

	contracts to create and maintain transparency in the supply chain."
SKILL 7	"**Digital Partnership Management skills** in purchasing include personal communication to solve issues with internal and external stakeholders in the Industry 4.0 environment that goes beyond electronic system communication."
SKILL 8	"**Digital Negotiation skills** include negotiating within a digital environment, where Industry 4.0 negotiation will focus on machine negotiation and digital market places."
SKILL 9	"**Digital Leadership skills** address the ability to organize and manage people within a digital environment based on activities and performance indicators that are provided by digital systems."

3.3. Selection of knowledgeable experts as Delphi experts

Due to the nature of the Delphi methods, the study's outcome heavily depends on the selection of knowledgeable experts (Rowe et al., 1991). To ensure high reliability, only experts were invited who have a good understanding of digitalization in purchasing, the concept of Industry 4.0, and an understanding of human resource management in the sense of professional roles and skills. For this reason, an open invitation was placed, which included a short questionnaire as a self-assessment addressing the level of knowledge within these areas. The methodology of self-rating has been confirmed as a legitimate instrument for selecting panels (Rowe and Wright, 1996). Further, additional experts were invited by personal contacts of the researcher. To achieve a high level of heterogeneity and to reduce various participants' cognitive biases, such as framing bias and anchoring bias, desirability bias, and the bandwagon effect, a selection was made. Heterogeneity was achieved through the includement of different industry sectors, firm sizes, and academia. In total, 70 experts were invited, where 47 experts responded, which included 37 experts from industry and ten from academia. From a professional perspective, these experts included procurement directors, supply chain management directors, managing consultants, chief procurement officers, purchasing managers, global sourcing managers, strategists, procurement HRM specialists, professors, and researchers.

3.4. Execution of the internet-based real-time Delphi study

For the study objectives, an internet-based real-time Delphi approach using the Calubrum Sureveylet software was applied. It was possible to facilitate the quantitative analysis of the experts' assessment within this software immediately. Further, in the form of comments within the survey, qualitative reactions were directly feasible by all experts after concluding the projections' initial assessment. This variant of the Delphi allowed a fast return and iteration of feedback to the experts compared to the conventional Delphi study approach.

For the quantitative assessment, all participants were asked to rate the projections within the Delphi survey according to three measures:

Agreement with the name of the role and skills and the formulation of the projection, based on a metric scale of 0-100% (0%=disagree, 50% neutral, and 100% agree)

1. Expected probability of occurrence, based on a metric scale of 0–100% (0% = low probability, 50% = neutral, and 100% = high probability)
2. Desirability of occurrence, based on a 5-point Likert scale (1 = very undesirable; 2 = undesirable; 3 = neutral; 4 = desirable; 5 = very desirable)
3. Impact on the industry, based on a 5-point Likert scale (1 = no impact; 2 = low impact; 3 = medium impact; 4 = high impact; 5 = very high Impact)
4. Level of adoption within the industry in a time frame from now, 5 years, 15 years, and 25 years (50% of all firms as the threshold), based on a metric scale of 0-100%

Also, experts could add qualitative justifications for their given quantitative estimates within the tool's comment function. Within this real-time Delphi, participants received feedback immediately after their initial assessment, where quantitative feedback was presented in the form of descriptive statistics and qualitative feedback in the form of other experts' written comments. Additionally, the software allowed experts to rate other experts' comments with an agreement rating on a 4-point Likert scale. Based on this real-time feedback, experts could reassess their provided estimates as often as desired until the end of the survey period. This scheme of returning the quantitative assessments and the qualitative comments to the participants allowed to increase the validity and reliability of the final results (Best, 1974). Within the work of Gnatzy et al. (2011), more detailed information on the conducted real-time Delphi approach can be found.

3.5. Analysing the real-time Delphi study results

As mentioned before, the outcome of the Delphi study provides qualitative and quantitative results. For the purpose of this research, both are analysed systematically. First, the qualitative results are analysed based on numerical values, and second, the quantitative results are assessed by analysing the comments and text input provided by the Delphi experts.

The first data analysis has been performed addressing the professional role and skills naming and description. Further, first intermediate insights on the quantitative assessments, the expected probability of occurrence, the impact on the industry, the desirability of occurrence, and the level of adoption within the industry.

To visualise the groups' long-term judgments for the expected probability of occurrence, the impact on the industry, the desirability of occurrence, and the level of adoption within the industry, their

respective arithmetic mean values were determined (Kopyto et al., 2020; Roßmann, Canzaniello, von der Gracht, & Hartmann, 2018). Further, the consensus and stability values were analysed in order to evaluate the feasibility of the projections.

Besides the quantitative assessment, the expert panel provided 411 written comments. These comments are analysed to improve role and skill descriptions and support the quantitative results. Thus, the final set of quantitative estimations are utilised for the discussion of the expert's long-term judgments.

4. Results: The Delphi study identified seven professional roles and nine skills within Industry 4.0 purchasing and supply management

The addressed projections were discussed within two months by the Delphi experts resulting in a list of future professional roles and skills needed for the transition of PSM in the era of Industry 4.0. Further, the Delphi study provided insights on the desirability, impact, and level of adoption of these roles and skills. Here the adoption level is assessed based on a timeframe from the present day, in five years, 15 and 25 years.

4.1. Defining roles, skills and the concept of Industry 4.0 within the Delphi study

Within the Delphi process, it became clear that an agreement on the definitions of professional roles, skills, the usefulness of roles and skills as organizational concepts, and Industry 4.0 was needed. These definitions were added to the Delphi survey, where participants rated their level of agreement based on a metric scale of 0-100% (0% disagree, 50% neutral, and 100% agree). The outcome of this definition of exercise is presented in Table 6. After implementing the definition page, fewer questions were asked to the study facilitator, and group consensus was improved. Since the agreement level with these definitions was high, no influence on the study results is assumed.

Table 6 – Additional definitions within the Delphi study

Category	Description	Consensus in %	Stability in %	Responses
Definition #1	A role can be understood as a concept for an organisation. Each role is bound to responsibilities and tasks within the organization. To carry out these tasks, each role requires a specific set of skills. One employee can have multiple roles or can be allocated to one specific role. One role can be divided across different individuals. Larger organizations will allocate one role to specialized employees. Smaller organizations will have employees with multiple roles.	85.85	75.77	47
Definition #2	Roles are concepts that allow for organizational development towards a higher maturity level. To allow a maturity increase, new roles will be implemented, and existing roles change, e.g., the skill requirements or tasks of these roles change. The set of skills and tasks of each role changes according to the available technology.	76.58	69.91	47
Definition #3	Skills are viewed as abilities learned by practice or knowledge acquisition.	87.23	78.27	47
Definition #4	Industry 4.0 is characterized by cyber-physical systems with autonomous machine-to-machine communication.	70.15	87.61	47

4.2. Exploring and assessing seven future roles in purchasing within the era of Industry 4.0

4.2.1. Describing seven new purchasing roles in the era of Industry 4.0

The Delphi started with 17 projections, eight addressing future roles, and nine future purchasing and supply management skills. During the Delphi process, multiple projections were changed. Some projections received minor changes, for example, the name of the role or skill. There was major changes in others, where the full descriptions of the projection were changed or even one projection was deleted. The changes within the role projections are described, and the quantitative output is addressed. Within the next section, the same analysis is presented for the skill projections.

After one week, two projections for the roles were changed significantly, including the Data Analyst and Value Manager and the Chief System Change Officer. Here, the experts suggested a significant change within the name and description of the projections. Due to this reason, two new roles were created, the Data Analyst and the Chief Happiness Officer. Further, implementing new systems was shifted from the Chief System Change Officer to the System Innovation Scout. The Chief Disruption Manager role was deleted because experts suggested combining this role with the existing Purchasing Risk Manager. For the roles, Robotic Process Automation (RPA) Manager, Data Maintenance Officer, Purchasing Innovation Scout, and the newly developed roles of the Data Analyst and Chief Happiness Officer, the experts suggested multiple names. A multiple-choice question assessed various suggestions, and the name with the maturity of votes was selected to decide which name suites best the description of the role. At the end of the Delphi, seven future roles were identified: (1) the Process Automation Manager; (2) the Data Analyst; (3) the Chief Happiness Officer; (4) the Supplier Onboarding Manager; (5) the Master Data Manager; (6) the System Innovation Scout; and (7) the Legislation Specialist. For each of these professional roles, the final description is presented in Table 7.

Table 7 - Projection results addressing future professional roles in purchasing and supply management

	Description	Consensus in %	Desirability	Impact	Adoption today, 5, 15 & 25 years in %				Stabi-lity in %
ROLE 1	"The **Process Automation Manager** works at the interface between purchasing and IT, responsible for implementing and operative running of RPA tasks within purchasing."	60.40	Desirable	High	18	43	48	**62**	56.28
ROLE 2	"The **Data Analyst** in purchasing is responsible for extraction and analysis of purchasing data to support the preparation of commodity strategies and complex purchasing projects."	80.37	Very desirable	High	39	**59**	71	73	68.00
ROLE 3	"The **Chief Happiness Officer** in purchasing is responsible for change	37.40	Neutral	Low	7	15	20	25	19.38

	management during system automatization and ongoing caretaking of human needs within a digitized working environment."								
ROLE 4	"The **Supplier Onboarding Manager** in purchasing is responsible for setting up the digital interface between the buying firm and suppliers, involving the harmonization of data and effective stakeholder communication."	63.83	Desirable	Medium	23	37	46	**52**	53.39
ROLE 5	"The **Master Data Manager** in purchasing is responsible for the alignment between the physical and digital world and ensuring data correctness and up-to-dateness."	67.42	Desirable	High	30	47	**62**	66	53.72
ROLE 6	"The **System Innovation Scout** is responsible for identifying and implementing new Industry 4.0 technologies or systems within purchasing."	59.55	Desirable	High	19	33	43	**53**	48.85
ROLE 7	"The **Legislation Specialist** in purchasing is responsible for ensuring that digital purchasing processes and sourcing projects comply with any relevant laws and regulations, including their implementation into the purchasing systems."	69.91	Desirable	Medium	26	38	45	47	57.52

*for the agreement with the definition

The Data Analyst:

Based on the quantitative outcome, the role of **the Data Analyst** stands out. This projection received a consensus value of 80.37% and stability of 68.00%, which indicates that the experts have a high agreement level with the role. The role is also highly desired, and a high impact on purchasing and supply management is assumed. The Data Analyst is responsible for the extraction and analysis of purchasing data to support the preparation of commodity strategies and complex purchasing projects. Within the Delphi, Expert 8 points out that the "*scope can vary depending on if you consider internal data only or both internal and external data*" (Expert 8). Based on this comment, it becomes clear that the Data Analyst's role is located within the intersection of procurement, within the interface between external and internal stakeholders. Further, the experts point out that the Data Analyst task also includes a certain data interpretation level. Here, Expert 12 mentions that *"this role has to be able to formulate hypotheses too and not just execute or implement and maintain data. The person in this position needs to know what will this information be used for on the category strategy or supplier negotiation"* (Expert 12). For multiple organizations, the role of a data analyst could already exist today. However, the importance of this role increases with the amount of data available. In the past, this role was focused on a small set of internal data. Moving towards Industry 4.0 in purchasing, the data available increases, including internal historical data of past contracts, requests for quotation or

offers, and newly available data such as market screening and supply risk analysis. The change in the data available was also pointed out by Expert 29. In the future, we turn towards "*purchasing big data*" (Expert 29). In the last maturity stage, the role of the Data Analyst includes the utilization of Artificial Intelligence. However, an Artificial Intelligence specialist's role was not addressed as a separate role since the experts connected this role to the Data Analyst during the Delphi study.

The Legislation Specialist:

Within the Delphi, the second-highest consensus was achieved for the role of the **Legislation Specialist** in purchasing with a consensus value of 69.91% and stability of 57.52%. Here the role is responsible for ensuring that digital purchasing processes and sourcing projects comply with relevant laws and regulations, including their implementation into the purchasing systems. The experts addressed that the "*Digital Legislation Specialist*" specification could be made (Expert 29). Using the word digital would shift the focus of the role more towards the digitalization aspect of purchasing, where more processes are automated and need to comply with the law. However, the role in purchasing would focus on both aspects since *"a legislation specialist is needed in procurement beyond digital"* (Expert 22). The rising importance of this role comes forth from the increasing importance of *"data privacy, which has been a major driver of this role"* (Expert 8). Nevertheless, the Delphi experts are unsure whether this role will be implemented within procurement or the legal department. On the one hand, *"compliance in purchasing is more and more important"* (Expert 9). On the other hand, this *"is a role in the legal team. Typically, legal will have people dedicated to procurement"* (Expert 9).

The Master Data Manager

The **Master Data Manager** received the third-highest consensus value with 64.42% and stability of 53.72%. This purchasing role is responsible for the alignment between the physical and digital world and ensuring data correctness and up-to-dateness. Within the Delphi, multiple names for this role were discussed, and the experts indicated their preference. Thes names and preferences include the Master Data Manager (52.36%), The Master Data Officer (26.32%), or Data Maintainance Officer (21.05%). In the end, the name Master Data Manager was selected based on the experts' comments and the fact that 52.36% selected this name. Today, the Master Data Manager's role is especially important since organizations implement new software solutions within different organization functions. However, multiple organizations might already implement this role, as it was stated by Expert 8: *"the more you have multiple ERP systems, the more you are likely to have this role already"* (Expert 8). Here, the comment refers to ERP systems but also more procurement-oriented systems, known as Supplier Relationship Management systems (SRM-systems), Purchase to Pay systems (P2P-

systems), e-procurement, and e-sourcing systems, which require experts to manage the alignment between all systems. Expert 15 refers here to *"data verification or audit,"* and Expert 22 addresses that *"a lot of data and new systems, ERPs, P2Ps will require someone to maintain/manage the data"* (Expert 15 and 22). Within the current transition phase, one central responsibility of this role becomes clear. This role is currently needed to ensure the alignment between the physical and digital world and ensure data correctness and up-to-dateness. Within this study, transforming paper-based data to digital data is considered as Industry 3.0 and earlier. Within the addressed Industry 4.0 context, the Master Data Manager is responsible for ensuring alignment between the physical and digital worlds, representing digital twins between both. This is also reflected by the experts' comments who noticed that in Industry 4.0, the role is *"limited to only digital alignment of data"* (Expert 7). Last, this role represents an interface role between different departments and is not managed by procurement only, since it should *"generally refer to data in the company"* (Expert 33), supported by the statement that *"the role can have a procurement a supply chain or an IT orientation"* (Expert 8). The Master Data Manager role's interface responsibility becomes especially clear by addressing the newly created digital link to suppliers and customers within the organizations' value chain. Here, understanding *"the role as an interface manager, so that client´s processes and supplier´s services/products understand each other perfectly"* (Expert 9).

The Supplier Onboarding Manager

Following the assumption that more systems will be implemented within the buyer-supplier interface, the fourth role, the **Supplier Onboarding Manager**, will be important. This role received a consensus of 68.83% and stability of 53.39%, which makes this role viable. Here, the Supplier Onboarding Manager in purchasing is responsible for setting up the digital interface between the buying firm and suppliers, involving harmonizing data and effective stakeholder communication. Also, for this role, the experts discussed multiple names, including the Supplier Onboarding Manager (74.36%), the Ramp-up Manager (7.69%), and the Contract Implementation Manager (17.95%). In the end, the Supplier Onboarding Manager with 74.36% of all votes was selected. It became clear that this role's responsibilities are onboarding suppliers to the organization's digital environments and practices, where *"onboarding also includes involving stakeholders, making contacts, explaining processes, etc., and making sure of all this works"* (Expert 10). The Supplier Onboarding Manager's role is especially needed during the first stage of supplier integration, where the link between the supplier and buyer for future business is created. Within the definition of Industry 4.0, advanced systems are able to run autonomously, which requires a flawless connection between stakeholders. The Delphi experts made clear that these connections are most likely established for *"supply chain data in high volumes*

production" and *"setting up digital interface is an IT Job and ensuring all interface fits well, the fit is purchasing responsibility"* (Expert 8). Indeed, for high volume production, *"the bigger the company, the higher the probability this role occurs"* (Expert 43). A well-established connection between the supplier and buyer allows for correct, up-to-date, and autonomous communication between both stakeholders. Addressing the whole supply chain's digitalization, it becomes clear that the most benefits are realized by *"achieving a complete supply chain digitalization"* (Expert 29). Here, the buying organization benefits from higher transparency towards higher-level upstream suppliers.

The Process Automation Manager:

The next role addresses the automation of processes in more detail. Here, the role of the **Process Automation Manager** received a consensus value of 60.40% and stability of 56.28%. The Process Automation Manager works at the interface between purchasing and IT, responsible for implementing and operative the running of Robotic Process Automation (RPA) tasks within purchasing. Addressing the purchasing process, already multiple operative purchasing tasks can be performed by an automated process, including the ordering and payment of deliveries. During the Delphi, the experts addressed first the name for this role based on four suggestions, including the Robotic Process Automation Manager (20.51%), The Robotic Process Automation Engineer (20.51%), the Process Automation Manager (51.28%), and the Process Automation Engineer (7.69%). The experts were discussing the name of this role in more detail. They decided to avoid the word "robotic", "the word robotic is not necessary in this context" (Expert 2), "Automation is already enough and is connected to semi-automated processes" (Expert 16). The opinion of *"using a more neutral name as robotic is getting much attention just now […] the real art is to develop and adapt processes to the new potentials out of robotics, artificial intelligence, etc."* (Expert 9). It became clear that the experts preferred a name that promotes the automation of processes in general. Experts also preferred the term "manager" since, as stated by Expert 8: *"I would say manager as there is a change management logic RPA is one technology automation can be done with other technologies"* (Expert 8). The Process Automation Manager role's importance becomes clear since this role organizes the responsibility for *"having one person responsible for end-to-end processes, which is always a clear benefit in automation projects"* (Expert 10). Looking at the task of this role, the *"Process Automation Manager, RPA Manager, in agreement with the purchasing and PSM departments, has to set up many big changes in the well-established process of administrative routines"* (Expert 21). The call for addressing the administrative routines shows that the automation of processes starts within the operational purchasing part. Here, "a *lot of routinary activities within PSM need to be automated"* (Expert 29). Within later technological developments of these automation systems, moving in Industry 4.0 towards autonomous systems, a

wider range of activities can be automated and run without human intervention. Within the Phase of moving towards Industry 4.0 in purchasing, this role is required to automate purchasing processes. However, within later stages, this role's importance decreases because advanced systems allow for autonomous processes.

The System Innovation Scout

For moving towards Industry 4.0 in procurement, a **System Innovation Scout** is needed to identify and implement new Industry 4.0 technologies or systems within purchasing. This role received a consensus value of 59.55% and stability of 48.85%. First, the Delphi experts discussed the name of this role by choosing between the options System Innovation Scout (35.14%), System Innovation Manager (27.03%), Purchasing Innovation Manager (18.92%), and Purchasing Innovation Scout (18.92%). By 35.14% of the votes, it was decided to call this role the System Innovation Scout, where it was clear that this role *"must contain the work System"* (Expert 2) since the focus is clearly on implementing software systems within procurement. However, the experts doubted if this role belongs to a manager or scouting position since *"the role can not stop at scouting"* (Expert 8), here the implementation of new technologies is also the role's responsibility. Thus, the role's responsibility is split into two dimensions, *"new technologies discovery"* (Expert 21), and the "*major challenge is companies innovation adaptability"* (Expert 23) which refers to the implementation of technology. In so far, the role *"this role could significantly shape the future of PSM"* (Expert 13). Here, the development of procurement towards Industry 4.0 can be seen as a step-by-step approach, where incremental changes, e.g., the implementation of new technologies, evolutionary development, are observed. To guide this process and identify suitable technologies, the role of the System Innovation Scout is needed. Within firms, *to ensure staying up-to-date IT-wise from a purchasing point of view," t*his role is needed in procurement because *"the IT-department itself is often focused on sales-software"* (Expert 43).

Chief Happiness Officer:

The last role addressed within the Delphi is the role of the **Chief Happiness Officer** in purchasing. This role is responsible for change management during system automatization and ongoing caretaking of human needs within a digitized working environment. However, based on the low consensus value of 37.40% and low stability of 19.30%, this role is less feasible in the future. Here, the experts of Delphi do not agree with the name and definition of the role. Also, selecting different names, such as the Chief Happiness Officer, the Employee Wellbeing Officer, or Chief Wealth Officer, did not help improve the group consensus. Addressing the name, the experts "*don´t like the word happiness in combination*

with work" (Expert 9) and have *"Lot of problems with the name"* (Expert 7). At the end of the Delphi, no new name for this role was found. Also, the experts had difficulties determining the responsibilities and scope of this role within business practices. Here, "*Change management is a temporary role ensuring positive engagement*" whereas "*happiness is ongoing (the HR function leads this in the most company) not sure these two roles are integrated*" (Expert 7). Thus, based on the research objective to explore future roles within procurement in an Industry 4.0 scenario, a role responsible for the human needs during the change process is required. However, this role needs a name and clearly defined. Further, where this role will be implemented is still questioned since this is not procurement specific and could be organized by firms' HR departments. This is supported by the comment of Expert 24, where the responsibility *"might be simply part of HR or the respective team leaders"* (Expert 24).

4.2.2. Assessing the impact and expected probability of future Industry 4.0 roles in purchasing

Within the quantitative assessment of the propositions the panelist assessed the expected probability of occurrence, based on a metric scale of 0–100% (0% = low probability, 50% = neutral, and 100% = high probability), and impact on the industry, based on a 5-point Likert scale (1 = no impact; 2 = low impact; 3 = medium impact; 4 = high impact; 5 = very high impact), of each role. The results of this assessment are resented in Figure 3.

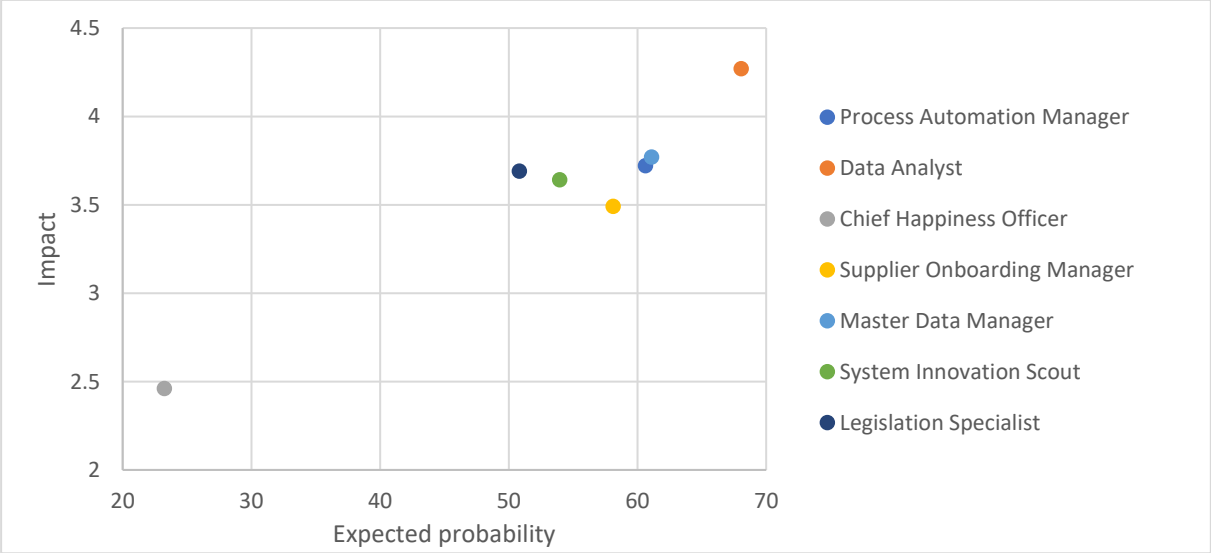

Figure 3 - Assessing the impact of each future roles in the industry by expected probability

The results show that the **Data Analyst** role scores very high, with an impact score of 4.27 and an expected probability of 68.07%. According to the experts, *"the impact is lower over the long term for internal data but high over the long term if this include external data"* (Expert 8). Here, it can be seen how the impact of this role changes over time due to the availability of data. First, the Data Analyst will analyze the internal data available, e.g., past offers and contacts, allowing a transparent view and comparing historical data. Next, the data analyst can support commodity strategy development within future projects by analyzing a larger amount of internal and external data. The strategic implications of this role become clear since this role *"would also help strategic sourcing, supplier risk management and supplier performance management using data*" (Expert 22). Here, for assessing supply risk and supply chain disruptions, "*supply market data analysis allows for early warning system"* (Expert 23). Last, the impact of the Data Analyst role is *"key to support the decision making"* (Expert 31), allowing for *"having a more informed decision-making process"* (Expert 29).

Further, the Master Data Manager (impact score of 3.77 and expected probability of 61.10%) and the Process Automation Manager (impact score of 3.72 and expected probability of 60.62%) significantly impact the industry. Addressing the impact of the **Master Data Manager** role, this role can be seen as "*the foundation"* (Expert 7) and *"boundary condition*" (Expert 23) for future system development and innovation with purchasing. Thus, this role can solve one "*main hurdle for a successful digital transformation"* (Expert 23). Here, "*the role is responsible for ensuring high data quality, which is still a recurring issue in PSM, preventing many procurement errors"* (Expert 10 and Expert 15). The Process Automation Manager's impact is *"not fully know at this point. However, data-driven decision-making and automated transactions are important to improve office work productivity and guarantee error-free transactions"* (Expert 2). In general, the impact of this role "*depends on the organization and the repetitive purchases to be done"* (Expert 7). Thus, the impact of this role addresses the efficiency of the purchasing process and error-free transactions. Here, **Robotic Process Automation (RPA)** is the current technology used. Within the next years, we will see this role as the "*RPA Manager, who works in agreement with the purchasing and PSM departments, has to set up many big changes in the well-established process of administrative routines*" (Expert 21).

Within the next years, a significant impact of the Legislation Specialist (impact score of 3.69 and the expected probability of 50.82%), the System Innovation Scout (impact score of 3.64 and expected the probability of 53.96%), and the Supplier Onboarding Manager (impact score of 3.49 and expected the probability of 58.13%) is assumed. Addressing the **Legislation Specialist**, this role does not bring larger benefits for the organization regarding efficiency increase or competitive advantages. This is explained by the comment of Expert 8, who describes that this role "creates burdens in the process more than

efficiencies... But this is needed". Thus, the Legislation Specialist role is not shaping the content of PSM future very much, but still very important" (Expert 13). The role is needed to meet law regulations, making "*this role is very important due to increasing regulations (e.g., GDPR)*" (Expert 28). Opposite to the Legislation Specialist role, the **System Innovation Scout** will significantly impact the efficiency and performance of purchasing, even leading to competitive advantages based on purchasing practices. Here, *"getting the right tools is a key factor in value creation"* (Expert 11). Thus, *"this role could significantly shape the future of PSM"* (Expert 13). For this role, it is important that the impact lies within the activity of identifying (scouting) suitable technologies for the firm within procurement and implementing these technologies within the business activities. To allow a high impact of this role, if it helps "companies innovation adaptability" (Expert 23) by supporting the implementation process. Further, a "*high impact in case the current purchasing organization lacks the right capabilities"* (Expert 29). The last role with a significant impact addresses the **Supplier Onboarding Manager**. Since this role is located within the buyer-supplier interface, *"the role will allow the automation of many activities with all the suppliers"* (Expert 30). Without this role, suppliers are less attracted to work with the buying firm. The buying organization will have to make sure that suppliers are able to connect to the supplier relationship systems used. Further, this role's impact is assumed to be high since it *"is fundamental to achieve a complete supply chain digitalization"* (Expert 29). Also, a well-managed onboarding process organized by a specialist allows *"integration of suppliers is much easier also, the change over cost and supplier dependency are decreasing"* (Expert 23).

Less impact is assumed for the Chief Happiness Officer role (impact score of 4.13 and the expected probability of 61.10%).

4.2.3. Assessing the adoption level of Industry 4.0 roles in purchasing

Within the Delphi study, also the assumed level of adoption of these roles was addressed. Here, the experts assessed when the firms would have adopted the described roles. The assessment was done for today's time period in 5 years, in 15 years, and in 25 years based on a metric scale of 0-100% (see Figure 4).

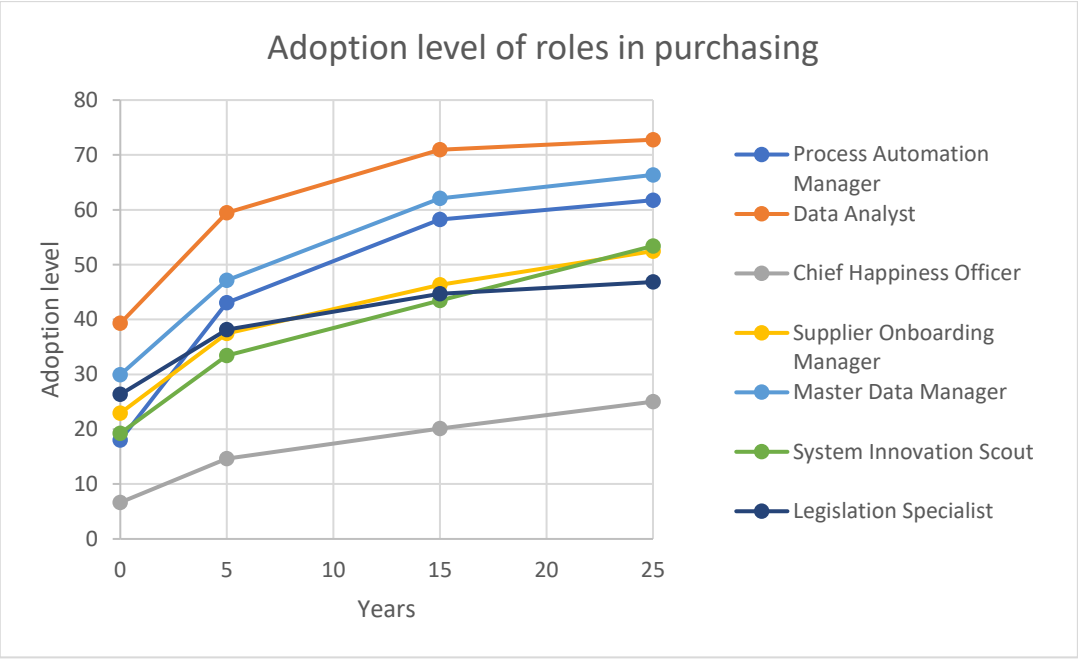

Figure 4 - Graphical illustration of the adoption of future professional roles in purchasing and supply management

This Delphi study's research objective was to identify future purchasing roles that are needed to develop forwards towards Industry 4.0 in the profession. However, the experts assessed multiple roles with a high adoption level within the industry (between 20%-40% already adopted these roles today). This outcome was not expected and could be explained by the characteristics and selection criteria of the sample of experts for this Delphi study. Because experts with knowledge in human resource management in purchasing, understanding of skills and competencies for purchasing professionals, and knowledge of digitalization or Industry 4.0 in purchasing were addressed, multiple experts were from larger organizations with advanced procurement practices. Since the **Chief Happiness Officer** did not seem to be a feasible role in future purchasing, this role received only a low adoption level.

The highest adoption level received the role of the **Data Analyst**. Here the experts assume that already 39.30% of the organizations adopted this role, and more than 59.46% will have adopted this role within five years. Based on the experts' assessment, 70.93% will have adopted the Data Analyst role in 15 years and 72.77% in 25 years. This makes the Data Analyst the most often implemented role in the future.

For the upcoming five years, the role of the **Process Automation Manager** is outstanding. Here the experts assume a relatively low adoption level of 18.02% within today's industry and a significant increase within the next five years to 43.07%. This increase shows that this role will be implemented within the short-term based on the available technology that allows the automatization of processes within procurement. The experts assume that *"just a few companies adopted this role, depending on*

the characteristics of the company and the level of digitalization, and most likely also by the role that the purchasing department plays within the company's digitalization process" (Expert 29). Also Expert 15 describes the characteristics more in detail, where *"big companies or specialized, or those with really scattered demands on procurement sourcing often from too many sources/systems"* (Expert 15) will have implemented the role today. Interestingly, the experts assume that this role's implementation could find a saturation point in the future where 58.23% will have adopted this role in 15 years and 61.75% in 25 years. Here, *"some equilibrium is gonna be created"* (Expert 15) because *"not all firms really will need it"* (Expert 9) and *"technology will develop so that there will be something else"* (Expert 33). Thus highly advanced technologies, e.g., Artificial Intelligence, could make this role redundant.

For the **Legislation Specialist** (adoption level today 26.34%, in 5 years 38.15%, in 15 Years 44.70%, and in 25 years 46.83%), the **Supplier Onboarding Manager** (adoption level today 22.93%, in 5 years 37.44%, in 15 Years 46.30%, and in 25 years 52.47%), and the **System Innovation Scout** (adoption level today 19.26%, in 5 years 33.45%, in 15 Years 43.48%, and in 25 years 53.41%) similar adoption level within the industry are assumed.

For the reason that multiple experts assumed a high adoption rate of these roles within the industry, an additional question was implemented within the Delphi survey, which askes for examples of the addressed roles within organizations, especially addressing how these roles are implemented.

4.2.4. Implementation of Industry 4.0 roles in procurement

After the Delphi experts assessed the assumed adoption level of the roles described above, a further question was implemented within the survey, addressing "how" these roles are implemented within the experts' organizations. Based on the provided comments, suggestions on how and where to implement these roles are made.

Process Automation Manager:

The first role addressed is the **Process Automation Manager**, who works at the interface between purchasing and IT, responsible for implementing and operating running of RPA tasks within purchasing. Expert 1 describes that *"the organization did not implement this role but are running small RPA projects in IT"* (Expert 1). Further, Expert 9 describes that *"so far only simple processes with very standardized actions have been implemented according to start small and simple and move towards bigger and more complex*" (Expert 9). At the current stage of technology, this is something general observed within the

industry. These projects start within the IT department, where there is sufficient knowledge available for these technologies. Within the next step, use-cases for technologies are explored, including, for example, purchasing activities. Here, the focus is on purchasing activities that are rather simple and repetitive. Implementing process automation or even robotic process automation (RPA) requires both *"knowledge both on process and technology"* (Expert 5), suggesting the responsibility within the interface of IT and procurement as stated by Expert 22: *"As this an interface role, is more towards a manger than an engineer, as this role will not program RPAs, but will translate business requirements from procurement to IT"* (Expert 22). In the special case of the organization of Expert 28 *"in the organization, an entire department works at the interface between purchasing and IT. They are responsible for implementing purchasing processes and systems. A small group of employees is responsible for RPA tasks."* This kind of role and function can also be called "*processes & tools*" (Expert 47).

Data Analyst:

The **Data Analyst** in purchasing is responsible for the extraction and analysis of purchasing data to support the preparation of commodity strategies and complex purchasing projects. Within the Delphi, it has been noticed that this role exists within several procurement organizations since it *"is part of the daily work of procurement teams to do the data mining. So the role exists in teams that work on major procurements, but usually not yet as an expert role"* (Expert 9). However, it can be assumed that this role will have to be implemented as an expert role within the future since more internal and external data becomes available within procurement. To abstract the full potential, a specialist is needed who holds the necessary skills to perform data analytics. For larger organizations, this role could exist multiple times, *"not only one person, but a team of data analysts will be responsible"* (Expert 4). Also, organizations could choose to implement a so-called *"business intelligence department, responsible for analyzing purchasing data and providing reports to purchasers"* (Expert 28). This role can be implemented on a corporate level, e.g., *"in Corporate Purchasing to provide data analyses for the whole organization. Responsible for, e.g., spend analysis, contract analysis, RFQ analysis, implementation of commodity strategy templates"* (Expert 13) or within *"category management teams and controlling"* (Expert 44). Looking at smaller organizations and organizations that will start to implement this role, the Data Analyst will most likely "*be implemented as a shared resource with other areas, e.g., finance"* (Expert 22).

Chief Happiness Officer:

Within the Delphi, the **Chief Happiness Officer** was addressed as the role responsible for change management during system automatization and ongoing caretaking of human needs within a digitized working environment. However, the experts did not see this role within purchasing in the future. Expert 8 states that "*change management is a temporary role Ensuring positive engagement (happiness) is ongoing (the HR leads this led of the function in most company).*" Further, Expert 24 states that *"this responsibility might be simply part of HR or the respective team leaders."* In this sense, if this role exists within organizations, this responsibility will most likely be shifted towards the human resource management department and not be implemented in purchasing.

Supplier onboarding manager:

The **Supplier Onboarding Manager** in purchasing is responsible for setting up the digital interface between the buying firm and suppliers, involving harmonizing data and effective stakeholder communication. Based on the roles' responsibilities, this role is located within the buyer-supplier interface. Multiple organizations have implemented this role as a *"Supply Chain Manager"* (Expert 4) or *"Vendor Management"* (Expert 12). Implementing this role within a digital environment becomes important since a linkage between both stakeholders is created. Currently, *"in an organization, there is an online portal specifically dedicated to suppliers. Via this portal, suppliers receive information and upload required data"* (Expert 28). However, from a buyer's perspective, this is rather a passive approach. In the future, more attention is needed to establish a more advanced connection between both parties. As it was described by Expert 13: "*The Supplier Onboarding Manager gives access to the Supplier Portal Purchasing to suppliers and tracks the status of their application. Later on, further functions need to set up their digital interfaces such as Logistics and Quality."* First, the Supplier Onboarding Manager manages the initial connection between the buyer and supplier. In the next steps, significant parts of the supplier relationship management are managed through the system, such as ordering, order tracking, payment, supplier evaluation, and quality management. The importance of this role increases within Industry 4.0 since various tasks are running autonomously within a cyber-physical system.

Master Data Manager:

The **Master Data Manager** in purchasing is responsible for aligning the physical and digital world and ensuring data correctness and up-to-dateness. The importance of this role increases, and organizations started to implement this role across s the whole organization, as described by Expert 22: "in the process to implement this role as a shared resource for the entire organization" (Expert 22). Also, the organization of Expert 28 where the "*business intelligence department performs the task"* (Expert 28).

Implementing this role as a central resource makes sense since the amount of data available increases within the whole organization. Further, it ensures the alignment of existing data throughout the whole organization. However, the data must become available for the purchasing department since the "*Master Data Management is essential, e.g., regarding supplier contact data, delivery and payment conditions in contracts or product master data cleaning before sending out RfQs"* (Expert 13). To achieve this, the Master Data Manager was implemented within the organization of Expert 13 within decentral purchasing. Besides, the organization of Expert 44 implemented this role within *"the category management teams"* (Expert 13). Independent of where the role will be implemented, it is important that this role is managed actively. Here, *"the goal is to manage the role, design, plan actively, and develop the data management as efficiently and effectively as possible - in co-operation with the suppliers"* (Expert 9). Active data management allows to benefit from the data, having a higher impact on purchasing performance, and prepares the introduction of future technologies within procurement, moving forwards to Industry 4.0.

System innovation scout:

The **System Innovation Scout** is responsible for identifying and implementing new Industry 4.0 technologies or systems within purchasing. Here, the role is *"an approach to emphasize the role and give it more weight via a more professional approach"* (Expert 9). Today, this role is not "fully implemented in organizations in a structured way" where "several purchasers watch out for system innovations on conferences, via networking, etc. and discuss whether this new innovation might be of any benefit to the organization" (Expert 13). Taking a more professional approach for this role would include the *"implementation of the role in the purchasing department"* (Expert 4), which allows identifying the purchasing departments' needs, formulate requirements and scout suitable technologies. There are multiple technological solutions available within today's market, but the assessment of technology requires both knowledges of the internal processes and characteristics of the technology. Here it is important to find the link between the maturity of purchasing and the future implemented technology. Most often, to assess the usefulness of the technology, a "*small pilot project*" (Expert 28) within the organization will be implemented.

Legislation Specialist:

The **Legislation Specialist** in purchasing is responsible for ensuring that digital purchasing processes and sourcing projects comply with any relevant laws and regulations, including their implementation into the purchasing systems. For larger organizations, "*the role is implemented within Corporate Purchasing, as legislation specialist is needed for the whole group in purchasing function. The specialist*

is responsible for both digital and analog purchasing processes" (Expert 14). For medium-sized organizations, this could be different, where for example, this is the responsibility of the category manager and the legal department" (Expert 44) or the role is "is part of the central legal function in the organization" (Expert 22). However, the role will require specific knowledge within the purchasing field. Within a central legal department structure, specific purchasing knowledge is required, which can be realized by "*specializing the legal department into different business functions. One of them is purchasing. They consult colleagues who are responsible for implementing purchasing processes and systems"* (Expert 28), developing towards Industry 4.0 in purchasing, the complexity of automated or autonomous processes' legal requirements increases, making this role more relevant for future purchasing activities.

4.3. Exploring and assessing nine future skills in purchasing within the era of Industry 4.0

4.3.1. Describing nine future skills purchasing skills within an industry 4.0 era based on the introduction and use of new technologies in PSM

During the Delphi study process, only minor changes were made for the projections addressing future PSM skills. These minor changes concern mostly skills titles or additions to the descriptions. In contrast to the roles, no skills were added or deleted. For the original Strategic Mindset skills, the new title Strategic Management skill was suggested and selected, and for the Holistic Supply Chain Management skills, the renaming Supply Network Management skills are used. Also here, to decide which name suites best the description of the role, various suggestions were assessed by a multiple-choice question, and the name with the maturity of votes was selected. For example, for the Supply Network Management skills, the experts suggested the word "supply network" since the skill includes understanding the vertical and horizontal supply chain of goods and services, which exceeds the term "supply chain" with the vertical and horizontal perspective. A detailed description of all nine skills identified is presented in Table 8.

Table 8 - Projection results addressing future skills in purchasing and supply management

Cate-gory	Description	Consen-sus in %	Desirability	Impact	Adoption today, 5, 15 & 25 years in %				Stability in %
SKILL 1	"**Data Analytics skills** within purchasing include handling, analyzing, and interpreting large amounts of data by using data mining and visualization to identify and solve problems, which allows for understanding the potential and impact of decisions."	84.56	Desirable	High	39	**57**	70	73	70.74

SKILL 2	"**Strategic Management skills** in purchasing includes the up-to-datedness with current global trends, e.g., Industry 4.0, and assessing their contribution for competitive advantage by considering them in commodity strategy development and corporate strategizing."	68.33	Desirable	High	39	**53**	62	69	57.43
SKILL 3	"**Supply Network Management skills** in purchasing relate to a coherent and integrated understanding of the vertical and horizontal supply chain of goods and services, which allows management of the supply chain from economic and environmental perspectives."	73.31	Desirable	High	38	46	**62**	64	65.13
SKILL 4	"**E-Procurement Technology skills** will be based on the growing functionality and scope of operational purchasing technologies, e.g., catalog-based purchasing. These skills focus on working with these systems and define future system development requirements."	83.18	Desirable	High	39	**58**	72	79	71.37
SKILL 5	"**Robotic Process Automation (RPA) skills** include implementing RPA in purchasing by configuring software bots to capture and interpret applications for processing a transaction, manipulating data, triggering responses, and communicating with other digital systems."	77.62	Desirable	High	17	36	**51**	63	72.70
SKILL 6	"**Digital Contract Management and Legal skills** to implement legislative and other legal requirements into automated purchasing processes, utilizing, for example, blockchain technology and smart contracts to create and maintain transparency in the supply chain."	69.64	Desirable	Medium	18	29	41	47	56.69
SKILL 7	"**Digital Partnership Management skills** in purchasing include personal communication to solve issues with internal and external stakeholders in the Industry 4.0 environment that goes beyond electronic system communication."	65.67	Desirable	High	24	37	**51**	59	52.19
SKILL 8	"**Digital Negotiation skills** include negotiating within a digital environment, e.g., E-Sourcing technologies and auctions, where Industry 4.0 negotiation focuses on machine negotiation and digital market places."	73.24	Desirable	High	25	39	**55**	63	61.54
SKILL 9	"**Digital Leadership skills** address the ability to organize and manage people within a digital environment based on activities and performance indicators that are provided by digital systems."	78.93	Desirable	High	24	42	**56**	63	68.22

*for the agreement with the definition

Data Analytics skills:

Data Analytics skills received the highest consensus value with 84.56% and stability of 70.74%. Data Analytics skills within purchasing include handling, analyzing, and interpreting large amounts of data by using data mining and visualization to identify and solve problems, which allows for understanding the potential and impact of decisions. The importance of Data Analytics skills becomes clear by the comment of Expert 4, who describes that "*Data analytics is more than a skill; it is a job*". The Data Analytics skills in purchasing include *"not only the verification of the impact of future decisions but also to analyze past decisions and future scenarios"* (Expert 4). Especially within the field of developing scenarios and evaluating decisions, a large amount of data is necessary. Within the definition of these skills, the term Big Data analytics is not used. However, Big Data analysis is also included within the Data Analytics skills, corresponding to these skills' high maturity. Here, the experts commented that Data Analytic skills or Big Data analytic skills are *"related to the existing analytic skills"* (Expert 7), but *"the Data Analytic skills are more focussed on (large amounts of) data"* (Expert 7). Further, these skills include *"the identification of problems and creation of hypothesis. With Data Analytics, the answers will be found"* (Expert 12). Here, for data analytics, the purchasing professional will be *"supported by business intelligence and data visualization tools"* (Expert 8). Moving forwards towards Industry 4.0, data analytics in purchasing will include the use of artificial intelligence. The purchasing professional will use artificial intelligence to analyze large amounts of data to identify and solve problems within the procurement context.

E-Procurement Technology skills:

E-Procurement Technology skills received the second-highest consensus value with 83.18% and stability of 71.37%. E-Procurement Technology skills are based on the growing functionality and scope of operational purchasing technologies, e.g., catalog-based purchasing. These skills focus on working with these systems and define future system development requirements. According to the Delphi experts, these skills are *"a must-have"* (Expert 8 and 21) and already exist *"for several years, but are recognized recently"* (Experts 11). Here, "*E-Procurement is often only understood as catalog-based purchasing*" (Expert 17) but should also include more advanced supplier relationship management systems. This is recognized by Expert 22, who describes *"e-procurement is the future. For sure, companies will have or will be forced, e.g., by suppliers, to collaborate digitally."* Currently, the functionalities of Supplier Relationship Management systems (SRM-systems), Purchase to Pay systems (P2P-systems), e-procurement, and e-sourcing are increasing, allowing for a digital-like of the value chain. Purchasing professionals working with these systems need to be trained with the necessary skills to use these systems.

Digital Leadership skills:

Digital Leadership skills received the third-highest consensus value. These skills address the ability to organize and manage people within a digital environment based on activities and performance indicators that are provided by digital systems. Within the current developments towards digitized procurement, in its end-stage Industry 4.0, *"leadership skills to organize and manage an organization going through a digital transformation"* are needed *"(…) this is about people and the strategic contribution of PSM"* (Expert 8). Besides the aspect that leadership is needed within the process of digital transformation, also Digital Leadership skills are needed since management of people and teams *"will change due to the development of the digital tools"* (Expert 45), and *"digital leadership should also include leading a remote-team"* (Expert 42). During the data collection, the world was impacted by the COVID-19 pandemic of 2020-2021. This influenced lead to the fact that Digital Leadership skills were recognized. Here, *"COVID-19 has proved that these skills are a must"* (Exper 23), and the importance of the skills *"increased significantly during the COVID-19 pandemic (capability to manage your team via digital tools)"* (Expert 13). However, one challenge will be to increase transparency and track the performance of employees (Expert 44).

Robotic Process Automation skills (RPA):

Robotic Process Automation (RPA) skills include implementing RPA in purchasing by configuring software bots to capture and interpret applications for processing a transaction, manipulating data, triggering responses, and communicating with other digital systems. The skill description is oriented towards working within an environment where robotic process automation is used, *"not all procurement people will need to program a bot. However, all procurement people must know they exist and their functionalities"* (Expert 22). These skills are assumed to be important within the short-term in procurement and that "many companies will rely on external companies to support them with RPA" (Expert 4) implementation. Here, firms will have to find expertise to implement RPA correctly since a *"wrongly prepared and/or executed RPA lead to disaster"* (Expert 10). Within purchasing especially repeating processes can be automated by robotic process automation.

Supply Network Management skills:

Supply Network Management skills in purchasing relate to a coherent and integrated understanding of the vertical and horizontal supply chain of goods and services, which allows management of the supply chain from economic, social, and environmental perspectives. Due to the increasing digitalization and use of technology within the buyer-supplier interface, transparency within the supply chain increases. Within the Delphi, it was addressed that also a horizontal perspective is needed,

focusing on a supply network perspective. Further, the Delphi experts noticed that *"this is a critical weakness of existing procurement"* (Expert 30). Currently, the focus is on transparency towards the first-tier suppliers. Looking at contextual changes, e.g., sustainability concerns in PSM, this skill is connected to the *"increased attention for green supply chains, therefore, increased need for environmental perspectives skill"* (Expert 22). Besides, it was mentioned that the social aspects should also be included in this skill (Expert 28). Within the highest maturity level, moving towards Industry 4.0, *"I4.0 technologies can be used, utilizing AI, but for the moment, good professionals make the difference"* (Expert 12).

Digital Negotiation skills:

Digital Negotiation skills include negotiating within a digital environment, e.g., E-Sourcing technologies and auctions, where Industry 4.0 negotiation focuses on machine negotiation and digital market places. By the experts, it was noticed that "E-sourcing will be the norm in the future" (Expert 22). Looking at the current stage of these digital negotiations, often, a human-machine interface is used. Where for example, *"some negotiations are supported by digital tools, in this context, the negotiation skill is to use the right tool at the right time and prepare the tool with the right parameters"* (Expert 8). Moving towards Industry 4.0, digital negotiation will include the machine-machine interface. Within this scenario, machine negotiation addresses "the automated negotiation or machine-to-machine negotiation. It will be increasingly important for purchasers to decide when face-to-face and when machine-to-machine negotiations are appropriate" (Expert 27). Digital Partnership Management skills.

Digital Contract Management and Legal skills:

Digital Contract Management and Legal skills to implement legislative and other legal requirements into automated purchasing processes, utilizing, for example, blockchain technology and smart contracts to create and maintain transparency in the supply chain. Within the digital transformation, this skill relates to the *"contract management supported by systems (…) and this skill is needed by most buyers"* (Expert 8). Further, the second part of this skill addresses the legal implications. Within the digital transformation and the increasing digital link between the buyer and the supplier, the legal environment changes. These changes are *"a high legal necessity, not really a company's voluntary choice"* (Expert 19) and need to be addressed by the organization. Towards Industry 4.0, the implementation of *"blockchain technology and the smart contract will be done by a project team and then can be used by the purchasing"* (Expert 8). This skill remains questionable whether this is a purchasing skill or an interface skill between IT and the legal department.

Strategic Management skills:

Strategic Management skills in purchasing include the up-to-datedness with current global trends, e.g., Industry 4.0, and assessing their contribution for competitive advantage by considering them in commodity strategy development and corporate strategizing. Implementing new technologies and practices within purchasing is a highly strategic skill, especially within the current digital transformation towards Industry 4.0. This also includes the *"ability to understand a problem in a global context"* (Expert 22). Within PSM, this skill focuses on the combination of including new technologies, practices, and *"harnessing supplier capabilities"* (Expert 8) by, for example, the *"strategic choice of new suppliers"* (Expert 4) since the technological developments allow for closer integration of the supply chain, the importance of the Strategic Management skills increases.

Digital Partnership Management skills:

Digital Partnership Management skills in purchasing include personal communication to solve issues with internal and external stakeholders in the Industry 4.0 environment that goes beyond electronic system communication. The Digital Partnership Management skills focus on the developing intersection between buyers and suppliers in line with the Strategic Management skills. Here, *"digital solution increase buyer-supplier integration and some extra work is included for some suppliers"* (Expert 8). However, the Delphi experts noticed that this skill connects with the existing skill of *"the general Relationship Management skills in a digital environment"* (Experts 13). The criticism of this skill is also shown by the lower consensus value of 65.67%. Developing towards Industry 4.0 in purchasing and an adopted supplier interface, the Digital Partnership Management skills characteristic has to be assessed in more detail.

4.3.2. Assessing the impact and expected probability of future Industry 4.0 skills in purchasing

Figure 5 displays the expected probability (0-100 scale) of the nine skills and its' impact (5-point scale). Data Analytics skills and E-Procurement technology skills show the highest expected probability and impact. This relates to the fact that these skills will be significantly important within the future years of purchasing. Digital Leadership skills, Supply Network skills, Strategic Management skills, and Digital Negotiation skills were assessed in the middle. These skills are expected to impact the field within the medium timeframe. Digital Partnership Management skills, Robotic Process Automation (RPA) skills, and Digital Partnership Management skills are less viable (see Figure 5).

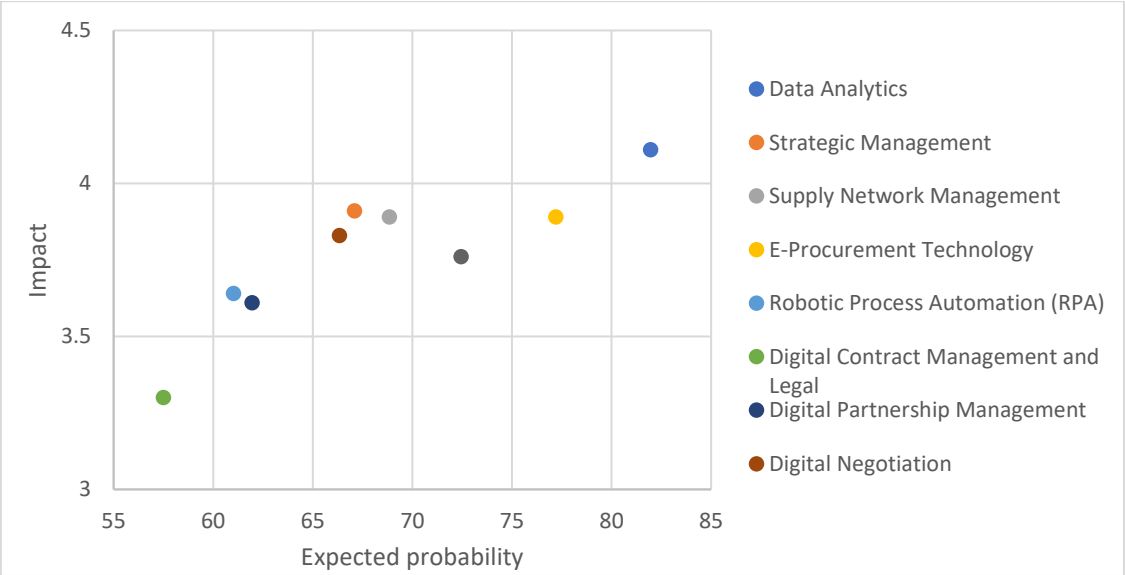

Figure 5 - Assessing the impact of each future skills in the industry by expected probability

4.3.3. Assessing the adoption level of Industry 4.0 skills in purchasing

Delphi experts assume that many firms already adopted addressed future skills today (see Figure 6). Again, the experts assessed when the firms would have adopted the skills. The assessment was also done for today's time, in 5 years, in 15 years, and 25 years based on a metric scale of 0-100%. However, the results are in line with the assumption that firms first adopted Data Analytics skills and E-Procurement Technology skills. Next, Digital Leadership skills, Supply Network Management skills, Strategic Management skills, and Digital Negotiation skills. Last, Digital Partnership Management skills, Robotic Process Automation skills, and Digital Contract Management skills (see Figure 6).

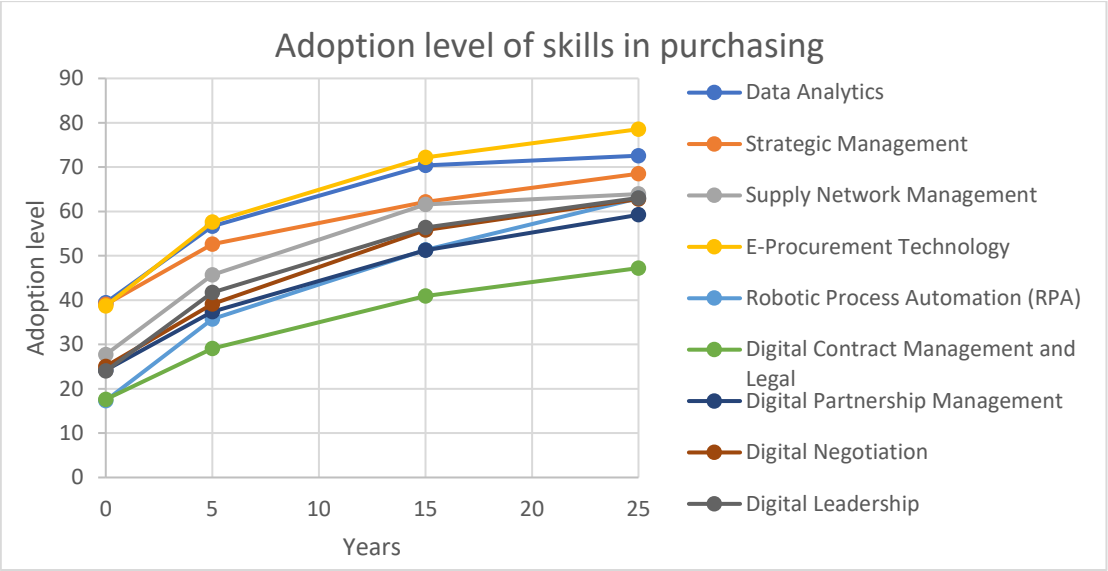

Figure 6 - Graphical illustration of the adoption of future skills in purchasing and supply management

4.3.4. The importance of interpersonal (human to human) and intrapersonal (character traits) will increase within the Industry 4.0 environment

The outcomes of this and earlier studies in project PERSIST reveal a broad palette of competence that urges to elaborate and to interpret the educational and (PSM) skills literature. As mentioned earlier, Industry 4.0 will significantly impact the PSM function, leading to another palette of required competencies (e.g. Bals et al., 2019; Glas & Kleemann, 2016; Schulze & Bals, 2020). This research found nine of those new competencies on which the experts in the Delphi study reflected. On the one hand, the experts assume that PSM practitioners increasingly need specific knowledge and, on the other hand, personal and professional skills. For instance, a *competent* Strategic Manager is characterized by strategic management knowledge, professional management skills, and applicable traits or attitudes; a mix of knowledge, skills, and attitudes (e.g. Campion et al., 2011; Delamare-Le Deist & Winterton, 2005).

The experts refer to these three elements of competence. Purchasers require personal skills, as 'strategic thinking', as confirmed in the literature (e.g. Bals et al., 2019). Moreover, purchasers need to adjust to change and need to solve complex problems. The experts stated that purchasers need capabilities to "understanding" and "overseeing". It requires innovativeness, inventiveness or creativity (e.g. Kiratli, Rozemeijer, Hilken, de Ruyter, & de Jong, 2016). The growing importance of these personal skills and traits is in line with the study of Von der Gracht et al. (2016), who researched future PSM skills and predicted existential threats when in a *"war on talent",* competing organizations recruit the most *"creative and innovative minds"* (Von der Gracht et al., 2016, p. 30).

Adequate knowledge, skills, and traits will be decisive in the upcoming era characterized by the Internet-of-Things, machine-to-machine communication, and artificial intelligence (AI) in which the *"digital transformation is also transforming our society into a knowledge society"* (Von der Gracht et al., 2016, p. 10). The prediction is that the economy changes into *"a knowledge economy, or even into a 'human economy', where not only intellect but especially creativity, passion, character, and team spirit will make the difference"* (Von der Gracht et al., 2016, p. 10).

4.3.5. Educating the identified Industry 4.0 skills in purchasing

Interestingly, it appears crucial to assess the purchasers' full competence levels rather than 'just' knowledge and professional skills. Personal skills and attitudes are crucial for practitioners' knowledge and professional skills (Ahmed, Fernando Capretz, Bouktif, & Campbell, 2012). Moreover, the absence of personal skills and traits is more likely to be the reason for ending a labor contract than an absence of knowledge (Ahmed et al., 2012). Moreover, personal skills and traits *"are necessary actually to implement—to articulate a vision; to enroll others in possibilities; and to communicate values, standards, and expectations"* (Muir, 2004, p. 99). Hence, in Industry 4.0, PSM professionals need the full palette of competencies, including personal skills and traits. It is essential for institutions of higher education to prepare their students and to develop the full palette.

Nevertheless, most academic PSM courses and tracks do not learn and develop personal skills and traits (Birou, Lutz, & Zsidisin, 2016; Stinenbosch, 2017; Wong, Grant, Allan, & Jasiuvian, 2014). Bals et al. (2019) stated that lecturers in PSM higher education have to establish learning objectives that include future requirements caused by the challenges of Industry 4.0; however, Fawcett and Rutner (2014) concluded that PSM higher education is "*not evolving at the pace and in the way expected by professionals"* (Fawcett & Rutner, 2014, p. 181).

In higher education, a significant role is given to learning objectives on knowledge and theory, and in parallel, these courses are not equipped to develop personal skills and traits, which students need to apply in practice. Higher education probably failed to introduce personal skills and traits learning objectives because the learning objectives require other didactics and assessment methods. The triangle of content (learning objectives), form (didactics), and testing the learning result (assessing) is known as *constructive alignment*.

In *Constructive alignment,* two ways of thinking are combined: *"the first derives from constructivist learning theory and the second from the instructional design literature"* (Biggs, 1996, p. 347). Crucial in constructivism establishes the meaning of the learner's activities, impacting the teaching and

assessment methods (see Figure 7). The *"Instruction design"* aligns a course's learning objectives and the student's performance assessment methods. Constructivism is applied as the instructional design framework to create curriculum objectives *"in terms of performances that represent a suitably high cognitive level, in deciding teaching/learning activities judged to elicit those performances and to assess and summatively report student performance"* (Biggs, 1996, p. 347).

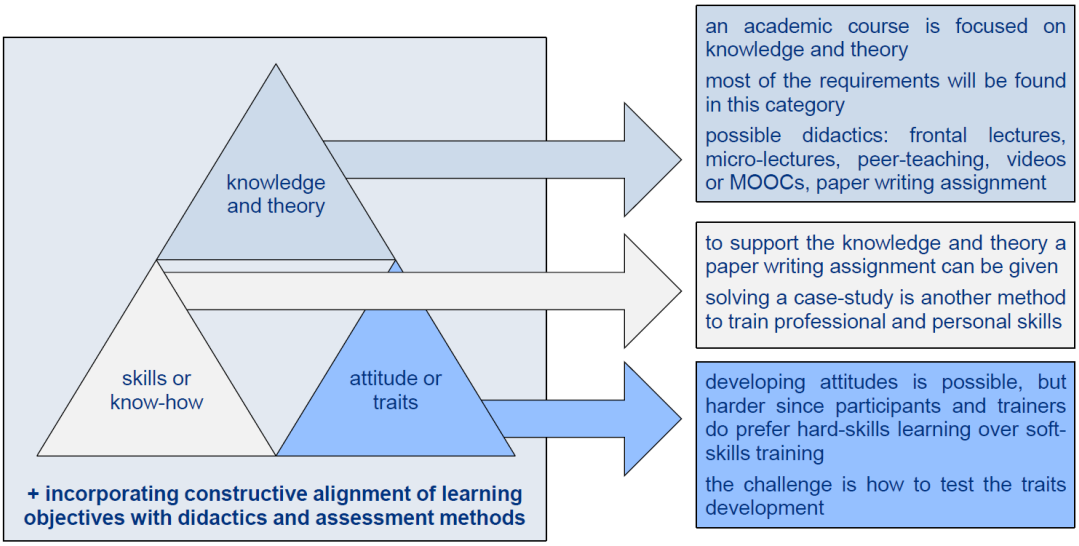

Figure 7 - Illustration of the constructive alignment concept

Project PERSIST aims to design and produce a course that prepares students for future roles as purchasers in Industry 4.0. Therefore firstly, the learning objectives need to be designed carefully. The full palette of knowledge, professional and personal skills, and traits or attitudes need to be considered. Next, the applicable didactical forms and methods for testing the learning outcomes have to be aligned. Knowledge (including theory) and professional skills can be learned via traditional didactics (instructions, paper writing, case studies); however, personal skills and traits require other didactics and assessment. Therefore Project PERSIST aims to introduce gamification elements as alternative didactics. The learning outcomes assessment could be measured in participation (attendance), the (sufficient) score in a game, or the individual student's in a reflection report and subsequent interview with the lecturer.

5. Discussion: Industry 4.0 purchasing skills and professional roles

5.1. Contribution to literature

This research contributes to the literature by adding and characterizing Industry 4.0 professional roles and skills within PSM. Research outcome shows that professional roles and skills are not a stable phenomenon but change due to environmental changes, such as technological changes (Spina, Caniato, Luzzini, & Ronchi, 2013; Zheng, Knight, Harland, Humby, & James, 2007). In the following, the contributions to literature will be presented, first focusing on future professional roles in PSM and second on emerging skills within the field. The outcome of this research supports the understanding of the work of Jones (2013) that professional roles can be understood as a concept of an organization, where each employee within a firm takes one or multiple roles, making him responsible for specific tasks and connecting specific skills to these roles to manage the associated tasks.

Starting with the contribution to PSM professional roles, the Delphi yielded a list of seven future purchasing roles. Thus, this research extends the five profiles of effective buyers within the work of Faes et al. (2001), the job profile research of Mulder et al. (2005), and the roles in purchasing developed by Schiele (2019) by detailed Industry 4.0 roles in PSM. The suggested professional roles in purchasing provide an understanding of how Industry 4.0 impacts the PSM profession. Here, the introduction of purchasing roles is a useful approach to implement future technologies within the firm incrementally. This concept of evaluating the impact of Industry 4.0 on professional roles is in line with the work of Fareri, Fantoni, Chiarello, Coli, and Binda (2020), which uses text mining to identify the impact of Industry 4.0 on job profiles. Further, the presented research is compliant with the work of Jones (2013) by organizing firm practices with the concept of professional roles, tasks, and skills. However, this research does not provide clustering of skills according to specific roles, as was suggested within the work of Faes et al. (2001). Last, this research is in-line with the work of Ulrich et al. (2013) confirmeing that there is less focus on the generalist as a role. Rather within the PSM field, increased attention on talent and human capital with a specialization is needed within future education, training, and recruitment.

Nevertheless, the second field of literature contribution addresses the description of specific Industry 4.0 skills in PSM. Here, the research complements the work of Bals et al. (2019) by exploring future PSM skills and describing already identified skills in more detail. Previous literature identified future skills as Analytical Skills, e-Procurement Technology skills, Holistic Supply Chain Thinking skills, and Strategic Thinking Skills. The presented research above gives a detailed description of these skills based on the Delphi study participants' discussion. Further, this research spots light on not yet discussed Industry 4.0 skills in PSM. Following Tassabehji and Moorhouse (2008) work, these identified skills

belong to the category of Technical Skills and Strategic Business Skills. A specific link between technological changes and future skill requirements is found. Besides, a first assessment of the importance/adoption level of these skills is provided. In combination with the work of Glas and Kleemann (2016) and Schiele and Torn (2020), the research provides further insights on how Industry 4.0 is influencing the purchasing field by taking a humancentric bottom-up approach, starting with purchasing skills, to implement maturing and emerging technologies with PSM.

5.2. Management can benefit from a list of Industry 4.0 professional roles and skills in PSM to prepare for the future

Within the presented research, the list of seven identified future purchasing roles can be used to develop further towards Industry 4.0 in purchasing. They are focusing on digitalization, data management, automation based on autonomous cyber-physical systems. However, to reach this stage, incremental steps will be taken, such as implementing the presented purchasing roles. Managers in purchasing, especially managers responsible for the purchasing employees and stuffing, find within this research guideline to evolutionary develop PSM towards Industry 4.0. In combination with the work of Jones (2013) or Schiele and Torn (2020), these purchasing roles can be implemented within the purchasing organization, increasing purchasing maturity. A bottom-up approach, starting with professional roles and purchasing skills, can help implement maturing and emerging technologies with PSM. Besides, the implementation of purchasing roles is depending on firm's characteristics, e.g., degree of digitalization of processes.

Within the presented research, the list of nine identified future purchasing skills can be used to develop further towards Industry 4.0 in purchasing. They are focusing on digitalization, data management, automation based on autonomous cyber-physical systems. However, to reach this stage, incremental steps will be taken, such as educating and training the suggested Industry 4.0 skills in purchasing. Especially managers responsible for the purchasing employees will find this research guideline to develop PSM towards Industry 4.0. In combination with the work of Glas and Kleemann (2016) or Schiele and Torn (2020), these purchasing skills are needed within the purchasing, increasing purchasing maturity. A bottom-up approach, starting with purchasing skills, can help implement maturing and emerging technologies with PSM. Within professional training and education, the addresses Industry 4.0 skills need to be educated within future study and training programs, utilizing appropriate educational methods. Within the educational field, the challenge will be to educate the existing workforce and to keep up with the fast-changing technological environment to educate the skills needed.

To ensure that the company is well-prepared for the future, human resource managers in PSM should focus on recruiting professionals with essential Industry 4.0 skills in purchasing or finding appropriate educational methods to train their employees in those skills (Giunipero, 2000b). Addressing the concept of continuous learning, educational professionals need to consider those currently working and future professionals who are currently acquiring the necessary skills within their study program (Bals et al., 2019; Pekkanen et al., 2020).

5.3. Limitations and future research

The research is limited to the research method applied. Here, the Delphi method is limited to the experts' knowledge. Here experts, are a good source of information if the information is limited. However, since this is a future-oriented study, it can not be assumed that the addressed propositions turn into reality. Also, Delphi is limited to 47 participants, which implies a low level of generalizability. Future research should focus on a larger scale of research, e.g., large survey study, to improve the results' generalizability. Also, the Delphi study is influenced by the Delphi facilitator's interference, which could influence the study results.

Besides the suggestions for future research due to the method applied, future research is also needed to find a way to implement the suggested roles within organizations. Also, a detailed set of skills is needed for each role to organize human resources management in purchasing and education. Here, Bals et al. (2019) provide a foundation on PSM skills that need to be allocated towards the identified purchasing roles. After this, future and current purchasing professionals can be educated and trained in specific purchasing roles, allowing for a higher specialization level (Pekkanen et al., 2020; Ulrich, Younger, Brockbank, & Ulrich, 2013). Also, this research is limited to the influence of new technologies on future purchasing roles. Future research needs to address the implication of content changes within the PSM field. For example, specific roles will be needed to cope with the identification of product innovation and sustainability within purchasing (Schiele, 2010; Schulze, Bals, & Johnsen, 2019). Last, the suggested future purchasing roles could be explored more in detail based on a maturity assessment. In this context, not all roles will be implemented within different purchasing maturity stages, and also, the capabilities and responsibilities of roles will depend on the availability of technology. Where for example, on the one hand, the Data Analyst role is based on internal data available within a low maturity stage of data available. On the other hand, in a high maturity stage, the Data Analyst will base his analyses on large amounts of internal and external data available, e.g., big data.

6. Next steps within the PERSIST Erasmus+ project

Within the next part of the PERSIST research project, IO4 focuses on the design of a module-based course concept for PSM with Gamification elements based on the outcomes of the Delphi studies. As a starting point, IO4 will use the identified skills and allocate these skills to the purchasing process in order to develop a course structure (see Figure 8). The aim of IO4 is to develop a module-based course that can be used within university study programs and professional training to educate future purchasing skills. Within IO5, the realization and validation of the module-based course, including learning material, will follow.

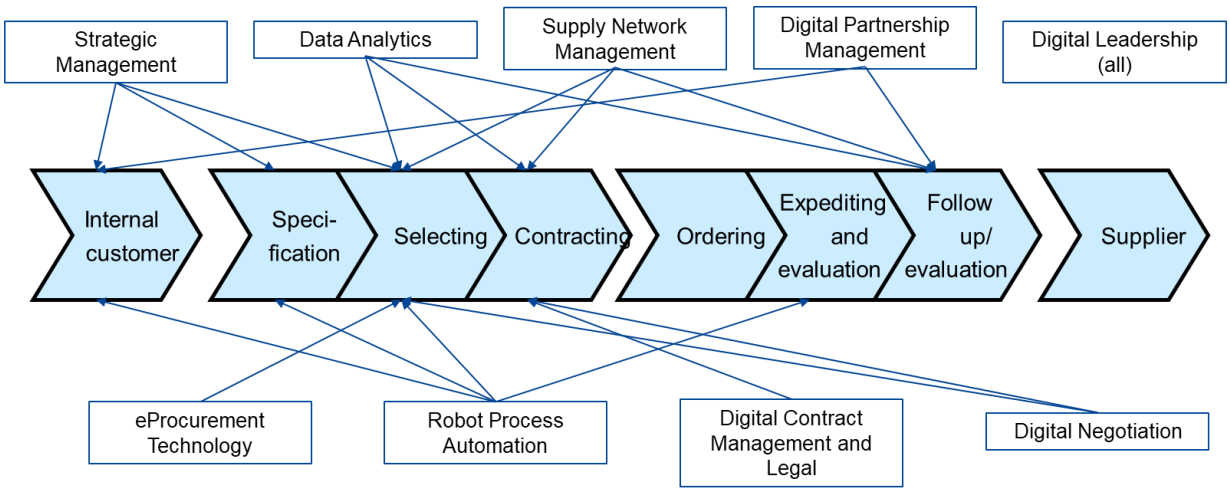

Figure 8 - Allocating identified future skills to the purchasing process as the starting point for IO4

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