

The Art and Science of Procurement: Revisiting Leonardo da Vinci

Editorial of the IPSERA 2019 Conference Special Issue

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Abstract

The IPSERA 2019 conference called for papers examining ‘the Art and Science of Procurement’ to explore the breadth of procurement research in a time of increasing focus on science and the scientific method. Taking a systems approach, a conceptual framework of procurement is presented as a multi-level field of study embracing art and science. Selected papers from the conference are summarised and positioned in the framework to explore how procurement research takes both art and science perspectives. This editorial concludes that, in the spirit of the IPSERA 2019 conference hosted in Milan on the 500th anniversary of Leonardo da Vinci’s death, revisiting more eclectic, holistic thinking might benefit the field of procurement to encourage both art and science in future research.

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1. Introduction

The theme for the IPSERA 2019 conference was ‘the Art and Science of Procurement’. The motivation for the theme for this conference in Milan, Italy, was inspired by the 500th anniversary of the death of Leonardo da Vinci. In particular, the duality of the work of Leonardo in its technical, engineering competence combined with artistic vision and emotion, resonated with the organising team’s reflections on the development of the field of purchasing and supply management (PSM). Since the 1960s when PSM researchers examined buyer behaviour, negotiation, and the dyadic relationship of the purchasing / marketing interface, the increasing dominance of operations and supply chain management has led to a greater focus on more tangible, hard aspects of the field, with increasing emphasis on scientific methods.

In this Special Issue devoted to the IPSERA 2019 conference, the guest editors explore ‘the Art and Science of Procurement’. This editorial aims to set the scene by reflecting on the development of knowledge creation from the time when universities provided broad education to individual students, enabling polymaths to examine the world from multiple perspectives, to the current day research in procurement. A knowledge development path is traced here from the Renaissance through the Scientific Revolution to a more contemporary return to holistic thinking embodied in the Systems Thinking movement.

The intent of this editorial is to reflect on the value that holistic approaches from both Art and Science perspectives might add to our field's development. Polymaths such as Leonardo da Vinci excelled at science, technology, engineering, philosophy, mathematics and the arts, and were representative of eclectic human endeavour to understand the world of medieval times. The Scientific Revolution of the 17th century transformed thinking and method, replacing eclecticism with the scientific method, forming the foundations of the modern-day world, and reducing knowledge into compartmentalised academic disciplines. However, critics of the scientific method find it insufficient to deal with complexity and interconnectedness. Systems thinking provides holistic approaches to understand unstructured problems of the real world (or 'messes', in Ackoff's (1994) terminology) that reductionist scientific methods struggle to comprehend.

To trace a knowledge development path and pay homage to Leonardo da Vinci on the 500th anniversary of his death, a brief *expose* of his holistic approach to Art and Science is provided here. The purpose of this editorial is to provide the canvas, frame and motivation for the creation of a new painting of procurement, one which learns from the master Leonardo da Vinci about combining art and science. Reacting to criticisms of a shift in PSM and supply chain management towards hard science, we provide a conceptual framework based on systems thinking. Through the positioning of selected papers from the IPSERA 2019 conference, it is argued that a more holistic approach to procurement combining art and science is required for research to tackle the complex, multi-faceted, interconnected, and unstructured problems practitioners in our field now face.

2. Leonardo da Vinci: the artist and the scientist

Leonardo da Vinci was born on the 15th April 1452 in Anchiano near Vinci in the Republic of Firenze (Florence), Italy at the beginning of a new era of humanism and Renaissance. Raised in Florence, he was apprenticed to the artist Andrea del Verrocchio and, at the age of twenty, was accepted into the painters' guild in Florence. In his early works of art there is evidence of a meticulous study of the perspective of an architect/engineer combined with the study of nature with the artistic expression of an acute observer. Leonardo believed that sight alone conveyed facts and experience and practised '*saper vedere*' or 'knowing how to see', as evidenced in the attention to detail in the painting *Landscape in Val d'Arno* (1473, *Galleria degli Uffizi, Firenze*). Known for his exceptional powers of observation, during this time Leonardo painted the *Adoration of the Magi*, (1481-1482, *Galleria degli Uffizi, Firenze*). In this masterpiece one can already see some of the many opposing and integrative perspectives of the artist. In particular, Leonardo was able to combine quiet and chaos, the geometry of space depth and human expression, all at the same time.

In 1482 Leonardo was drawn to Milan for the first time as '*pictor et ingeniarius*' - painter and engineer - to the Duke. The main reason why he was called to Milan was his engineering capabilities. Initially, he was involved primarily in the design of weapons and war machines to protect the Sforza's Duchy in a period of war. Subsequently, the Duke understood his great potential in designing also futuristic infrastructures to support the social and economic development of the city of Milan. The lock gates along the canals are a clear example of completely redesigning mobility, as reported in the *Atlantic Code* (1490-1497 *Biblioteca Ambrosiana di Milano*). These activities provide evidence of integrating very different and often opposing perspectives of developing a vision of the future and executing concrete projects to make it happen.

Notably during his Milanese period he created the ***Virgin of the Rocks*** (1483-1486, *Louvre, Paris*) depicting grace of movement, and ***The Last Supper*** (1495-1498, *Santa Maria delle Grazie, Milan*), demonstrating once again the ability to combine opposing elements: nature with human characters, geometry in the perspective and human emotions. These contrasting and integrating elements of geometry and the anatomy of the human being at the same time are also evident in the ***Vitruvian Man***, (1490, *Accademia di Venezia*).

As conflict in Milan increased, da Vinci returned to Florence for his second Florentine period from 1500-1508, which included a time away in service to the notorious Cesare Borgia as senior military architect and general engineer. Few paintings emerged from this time, though he did start the ***Mona Lisa*** (1503-1519, *Louvre, Paris*). Much of his effort during this period was spent sketching topography of the land, forming early cartographic maps, and drawing anatomy from studying dissected cadavers at the Santa Maria Nuova Hospital, showing the breadth of his eclectic approach in combining different perspectives of a very complex world.

Before his death on the 2nd May 1519, Leonardo da Vinci left Italy for good, spending his last days as a guest in the court of the king of France. His legacy is only 17 paintings still in existence and attributed to him, but his eclecticism across art, science, technology and architecture caused Vasari to identify him as the founder of High Renaissance.

3. From Renaissance to scientific method to systems thinking

Two main themes are developed. First the journey from Renaissance polymaths to specialisation and the scientific method is summarised. Next the systems movement, as complementary to reductionism of the scientific method is briefly examined.

3.1 Renaissance to the Scientific Method

Leonardo da Vinci was a polymath who, with others of his time, excelled at both the arts and science. Polymaths of the 14th to 17th centuries studied science, technology, engineering, philosophy, mathematics and the arts and sought to gain and develop knowledge from any perspective they felt informed their quest. When Leonardo was born in the new age of humanism, the excitement of the Renaissance was putting humans at the centre of thinking. Renaissance humanism viewed humans as limitless in their capacity to develop knowledge through excelling at a wide range of areas of expertise, spawning many creative schools of thought (Gray, 1963).

Universities of this time did not train students in specialisms but rather developed a universal education; a Renaissance Man was someone who was talented at many artistic, scientific and technical areas, able to soar in 'flights of the mind' at a time of both disruption and aspiration (Jones, 2009). The Italian Renaissance was highly influential on the humanist movement that spread across Europe for 3 centuries.

Art and Science have changed substantially since Medieval times, through Renaissance, Reformation, and the Scientific Revolution of the 17th century. The Scientific Method changed thinking and methods of study, developing reductionism, repeatability, refutation, empiricism and rationality, forming the foundations of the modern-day world and distinction of academic disciplines.

The Scientific Revolution saw a number of breakthroughs (Copernicus' explanation of the solar system, Galileo's development of mechanics and Newton's understanding of terrestrial and celestial dynamics; Hall and Dunstan, 1954) that led to two related major developments. First, they contributed to the scientific method, as explicated by Francis Bacon

(see Jardine, 1974) and second, they spearheaded a worldwide acceptance of the existence of, and quest to develop further, principles of the natural world (Russell, 1914). Regarding method, the twin pillars of empiricism and rationalism were installed in the building of science, influencing the shaping of the physical world of cities and transport, how we organize ourselves and how we think.

The rigour of science and the scientific method broke problems down into component parts to understand them better; however, Descartes's (1625) reductionism and the scientific method of repeatability and refutation lie at the heart of concerns about science being able to cope with complexity and interconnectedness of real-world problems. The development of so called 'restricted' physical sciences – physics and chemistry – have thrived as they have restricted the number of variables they engage, enabling experiments, theorising and laws to be developed (Pantin, 2010). Unrestricted sciences, such as biology, accept many more variables that are acknowledged to change, so deal with more complex, changing systems. All the social sciences are unrestricted; whilst in certain circumstances attempts to apply scientific methods of empiricism may provide some explanation of the social world, it is widely accepted that a body of general scientific laws has not been established for the social world (Nagel, 1961).

In business and management a similar evolutionary path can be observed. Entrepreneurs have traditionally been eclectic and polyvalent, able to develop technological innovations, create a business around them, recruit people and manage organizations, market their products, raise financial resources, orchestrate partnerships with suppliers and distributors, etc. Often such entrepreneurs were self-made, sometimes lacking formal education and training. The managerial field has developed over time far more specialised professions, leading to experts of different fields, from finance to marketing, from operations to human resource management.

3.2 Scientific Method to Systems Thinking

Criticisms of scientific methods' insufficiency to deal with complexity and interconnectedness of opposing elements has led to the development of modern-day 'systems thinking'. In contrast to reductionist scientific empirical approaches, 'systems thinking' and 'general systems theory' attempt to address complexity through 'holism'. Since World War II von Bertalanffy (1956) developed the foundations of systems theory from organismic biology, to a more generalised view of all systems including management systems (von Bertalanffy, 1972). Would the multi-faceted Leonardo da Vinci existing 500 years ago be described today as a 'systems thinker'?

In his seminal work 'Systems thinking, systems practice', Peter Checkland (1981) proposed that systems thinking is based on two pairs of principles of 'emergence and hierarchy' and 'communications and control'. In organised complexity, there exists a hierarchy of levels of organisation, each more complex than the level below. 'Emergence and hierarchy' are paired as each hierarchical level is characterised by emergent features that do not exist at the lower level; hierarchy theory is concerned with the differences between each level of complexity in the hierarchy (Simon, 1962). Von Bertalanffy (1956) proposed that systems open to environmental influence – open systems - require communication between different levels of the hierarchy to enable control of the system, in line with control systems thinking from cybernetics (Wiener, 1948), giving rise to the pairing of 'communications and control'.

Checkland (1981) argued that scientific, reductionist approaches should be complemented by systems thinking approaches to achieve a more holistic perspective of complex, real-world problems. Systems thinking is about 'holism', the whole being more than merely the sum of its parts (Jackson, 2003) i.e. a 'big picture' view.

This has been mirrored in business practice. While some entrepreneurs have been highly successful, leading their companies to grow and prosper, entrepreneurialism has also shown a number of limitations (Koiranen, 2002). The complexity of the modern business world exhibited through the acceleration of technological development, the rise of large global companies, the interconnectedness of global supply chains, the evolution of the financial markets, the articulation of legal systems and multiple competitive pressures have pushed towards the managerialisation of the business profession, i.e. the development of managerial roles, generally trained and educated in universities and business schools, more and more specialized in specific business areas and disciplines (Enteman, 1993; Koiranen, 2003).

Such focused professionals have been able to hone their managerial skills and competences, but only within the boundaries of their role. This is associated with greater emphasis on quantitative, data-driven approaches, in order to manage complexity by leveraging a scientific approach. A new tension has emerged: between the need for highly skilled specialists, who are inevitably focused on their domain of expertise, and the need for more generalist managers, able to bring together the various roles and areas of an organization, around a common vision and strategy (Parker, 2002; Delbridge and Keenoy, 2010).

More recently, entrepreneurs, in particular in the technology sector, have again caught the attention of the business community for their ability to develop disruptive innovations and revolutionize the entire society (consider the founders of Microsoft, Apple, Google, Facebook, Tesla, etc.) (Bygrave and Minniti, 2000; Baumol, 2010). Over-specialization hampers the ability to innovate and adapt to a turbulent context, while current complexity requires a broader and more holistic ability to comprehend and balance conflicting pressures and tensions. So today, managers need to be entrepreneurial (Harvey, 1989), and entrepreneurs need to be managerial, i.e. combining multiple skills and competences (Koiranen, 2003), being both rigorous and creative, scientists and artists, in a way similar to what Leonardo was 500 years ago.

4. Systems thinking in procurement

Bridging Leonardo's capability as a deep observer of multidisciplinary contrasts and connections to current procurement challenges, many opposing and complementary elements should be considered in the procurement profession. Procurement has a key role in increasing profitability of the company, but this role also needs to be integrated with creativity around broader strategic and policy-led roles, such as those supporting innovation and sustainability .

Buyers and procurement professionals assess and manage risks in their supply networks, but at the same time need to contribute ideas to create value. Digital technologies and data analysis are key factors in managing procurement activities, but simultaneously procurement professionals apply ethics in decision making and nurture internal and external human relationships. Geopolitical factors impact on supply markets, requiring a global long term outlook, but this is balanced by attention to continuous cost reduction in the shorter

run. Finally, successful CPOs must have a clear vision and long term strategy, but at the same time be able to execute and deploy flexible responses to handle the unexpected.

For all of these reasons, procurement professionals need creativity to scout for innovative solutions to unanticipated challenges and, at the same time, adopt analytical structure and quantitative reasoning to solve complex problems. Procurement, therefore, must combine art and science contrasts and complementarities, adopting a complex systems thinking approach. In order to be effective in modern and rapidly changing times, this procurement systems approach will increasingly need a similar eclectic approach as polymaths like Leonardo practised over 500 years ago.

4.1 The evolution of procurement competences and skills

PSM researchers have extensively investigated the skills buyers need to face challenges of their profession. Over the last few decades, several contributions have shown the evolution of these skills, corresponding to the evolution of the role of PSM within organizations and consequently of the profession itself. Table 1 presents an overview of some of the most significant contributions over time.

Authors, year	Contribution on procurement competences and skills
Kolchin and Giunipero (1993)	4 areas of competences: technical, management, interpersonal/group and individual
Giunipero and Pearcy (2000)	29 skills in 7 groups, including both soft (e.g. process management, team, behavioural and negotiation) and hard (e.g. strategic, decision making and quantitative)
Carr and Smeltzer (2000)	35 skills grouped into Technical Skills, Skill Techniques, Behavior Skills
Giunipero, Denslow and Eltantawy (2005)	Skills to achieve flexibility: Risk management, Interpersonal communication, Influencing and persuasion, Planning, Decision-making, Internal motivation, Creativity.
Giunipero, Handfield and Eltantawy (2006)	Skills to achieve strategic purchasing: Team-building, Cross-functional strategic planning, Communication, Technical skill, Broad financial.
Tassabehji and Moorhouse (2008)	Categorisation of Procurement Skills: technical, advanced procurement process, interpersonal, internal enterprise, external enterprise, strategic business
Feisel, Hartmann and Giunipero (2011)	Importance of the human aspect in PSM
Bals, Schulze, Kelly and Stek (2019)	The most important current competences are negotiation, communication and relationship management, strategy and analytics, and professional knowledge requirements. In addition, sustainability, digitisation and interpersonal skills are increasingly required.
Van Hoek, Sankararaman, Udesen, Geurts, Palumbo-Miele (2020)	Procurement executives identify new competences: Industry 4.0, talent development, sustainability, supplier enabled innovation

Table 1: Overview of contributions on procurement competences and skills

More recently, the project PERFECT (Purchasing Education and Research for European Competence Transfer) set out to develop empirically validated curricula for purchasing and supply management education. The PERFECT curricula are based on development of a wide range of skills and competences, including not only traditional, functional skills, tools and technology skills, but also soft skills, such as interpersonal and communication skills, and skills to enhance creativity, leadership and sustainability (see e.g. Bals et al., 2019). Although this is just a limited subset of the contributions that can be found in the literature on the topic, it shows clearly its evolution over time, with increasingly diversified skills required, combining both relational and technical ones, creativity and rigour, art and science.

5. Art and Science in PSM Research

PSM research has mirrored the evolution of the profession. In the early days the focus was mainly on relational, behavioural, qualitative issues, taking a 'soft' perspective (Wynstra et al., 2019). Subsequently the increased use of data analysis, mathematical modelling, simulation and optimisation approaches has contributed to a 'hardening' of the field. But today, as Artificial Intelligence, Robotic Process Automation and Big Data Analytics increasingly automate and rationalise procurement behaviour and processes, might the focus shift back to purchasing and supply management as it was taught and researched in the 1960s? That is, to a more relational, behavioural, social science. Should we endeavour to increase our understanding and teaching of the 'softer', more human side of the field, without losing the analytical and quantitative element?

This editorial proposes that procurement in practice is operating at multiple levels of organisation and complexity, whilst simultaneously tackling challenges that require hard analytical skills and methods, but also those requiring softer, more creative approaches. To deal with complexity and change, procurement needs modern day polymaths able to take different perspectives covering a spectrum from art to science, soft to hard methods.

Procurement may also need to use different approaches appropriate to the hierarchical level of system professionals are dealing with, moving from the point of view of individuals, functions, organizations and supply relationships through a broader view of supply chains and supply networks up to a potential impact on the whole supply system or supply market. But all of these systems levels can be analysed with different perspectives: an art approach, oriented to soft, human and relational aspects; or a science approach, oriented to scientific, engineering and quantitative aspects. Are these alternatives or are there opportunities to blend together these two perspectives? To answer this overarching question, a conceptual framework is proposed that combines both the art to science spectrum and the hierarchical systems level where PSM research is conducted, allowing a positioning of research according to both the systems level of analysis and the approach adopted. The conceptual framework builds on existing frameworks of levels of analysis in supply chain management, such as Harland (1996), extending these by adding further levels and differentiating approaches in procurement that represent art and science at each level.



Figure 1: The research framework

The research framework was used as a reference model to classify papers of this special issue (see Table 2 for a summary). In particular, each paper was classified considering the unit of analysis described in the paper: the unit of analysis was used to identify the system level more appropriate for each paper; then, the content was investigated to examine whether ‘art’ or ‘science’ predominates. In several cases, the authors blend art and science method and this combination to address the importance of two approaches to have an holistic approach to procurement.

ID#	Author(s)	Title	Methodology	Unit of analysis	Issues
1	Heike Schulze and Lydia Bals	Implementing sustainable purchasing and supply management (SPSM): A Delphi study on competences needed by purchasing and supply management (PSM) professionals	Delphi Study with Critical Incident Technique	Individuals	Buyers’ competencies
2	Niels Uenk and Suvituulia Taponen	Procurement practices for home care of Finnish and Dutch municipalities: a country comparison	Analysis of home care tenders and contracts of Finnish and Dutch municipalities	Public supply systems	Public procurement policy for service triads
3	Jolien Grandia and Peter Kruijen	Patterns in sustainable public procurement: an analysis of > 140.000 public procurement notices of Belgian contracting authorities	Text-mining of public procurement notices	Public supply systems	Supply procurement sustainability policy
4	Alessandro Ancarani, Carmela Di Mauro, Giulia Crocco and Florian Schupp	Learning to be risk averse: evidence from a multi-echelon supply chain	Observational study of managers playing the Beer Game simulation	Individuals	Buyers’ risk attitude

5	François Constant, Thomas Johnsen and Richard Calvi	Purchasing ambidexterity: how it contributes to firm's innovation capabilities	In-depth case study	Organizations	Purchasing function organization
6	Matteo Kalchschmidt, Sebastian Birolini, Mattia Cattaneo, Paolo Malighetti and Stefano Paleari	The geography of suppliers and retailers in the fashion-textile industry	Quantitative indexes of network spatial concentration and relative proximity measures based on a nonparametric kernel density estimator	Supply networks	Supply network structure

Table 2: articles included in the special issue

The papers included in this special issue represent a combination of art and science, illustrating the need to balance soft and hard skills in managing procurement appropriately. Table 3 summarizes the theoretical background, research and managerial contributions. The table is followed by a brief summary of each article.

ID#	Theoretical background	Research contribution	Managerial implications
1	PSM research blended with educational science and organizational psychology	The article develops a SPSM Competence Model at the individual level based on four competence clusters: 'cognition-oriented', 'social-oriented', 'functional-oriented' and 'meta-oriented' and providing priorities among them.	The competences and their descriptions are useful for setting higher education learning goals and contents. The competence model is a useful blueprint for companies who want to develop their own.
2	Service Triads and risk allocation	The article investigates risk allocation among the actors in the service triad based on buyer decisions in outsourcing and supply market conditions. Service triads with a public buyer do not fit existing service risk profiles aimed at private sector buyers.	The risk profiles of the actors in the home care service triad are affected by the purchasing practices of the public bodies. Contract types and consequent incentives impact the risk allocation among service triad actors.
3	Sustainable Public Procurement (SPP)	The article proposes the articulation of SPP in seven categories. Green public procurement is prevalent compared to other categories and there seems to be a relationship between the project size and the SPP category addressed.	SPP is actually more implemented in practice than expected, but the trend is declining. SPP is implemented with lowest price as award method.
4	Risk attitude, risk taking behavior, and experiential learning	The risk aversion of buyers matters in purchasing decisions, resulting in higher orders. Experiential learning improves performance by reducing order variability but does not reduce orders for risk adverse buyers.	Several bias affect individual risk perceptions and consequently performance, therefore de-biasing strategies are required.
5	Purchasing Ambidexterity	The article identifies four types of ambidexterity (structural, sequential, contextual and managerial) and discusses how these can be combined to mitigate tensions, identifying a two-stage process.	Findings show how companies can develop an ambidextrous purchasing function to facilitate purchasing's contribution to innovation exploitative and exploratory innovation.
6	Network design	The metrics developed in this paper improve the reliability of supply network models that consider the geographical	The proposed metrics allow assessment of the geographical distribution of complex supplier

		dimensions as a key factor, thus representing a valuable support in the evaluation and design of the most promising network settings.	and retailer networks and evaluation of the effect of operational changes, such as the need for a logistical facility in a specific location or the effects of offshoring and reshoring processes.
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Table 3: theoretical background and contribution of articles included in the special issue

The papers of the special issues are positioned in the conceptual framework, as shown in figure 2. Figure 2 shows the breadth of research in PSM in a small selection of papers from just one conference. These papers show how some authors, namely Uenk et al., Constant et al., and Grandia and Kruyer, have taken a polymath, art and science approach to PSM in a single piece of research. Kalchschmidt et al took a more ‘hard’, scientific approach, whereas Bals et al. and Ancarani et al. focused on softer aspects of the field. The two papers from public procurement – Grandia & Kryer and Uenk & Taponen – are examining PSM at a system level by researching contracts placed by public organisations. Grandia & Kryer use big data analytics to address softer issues in contracts around sustainability. Bals et al. and Ancarani et al. are researching at a far lower hierarchical systems level, investigating individual behaviours.

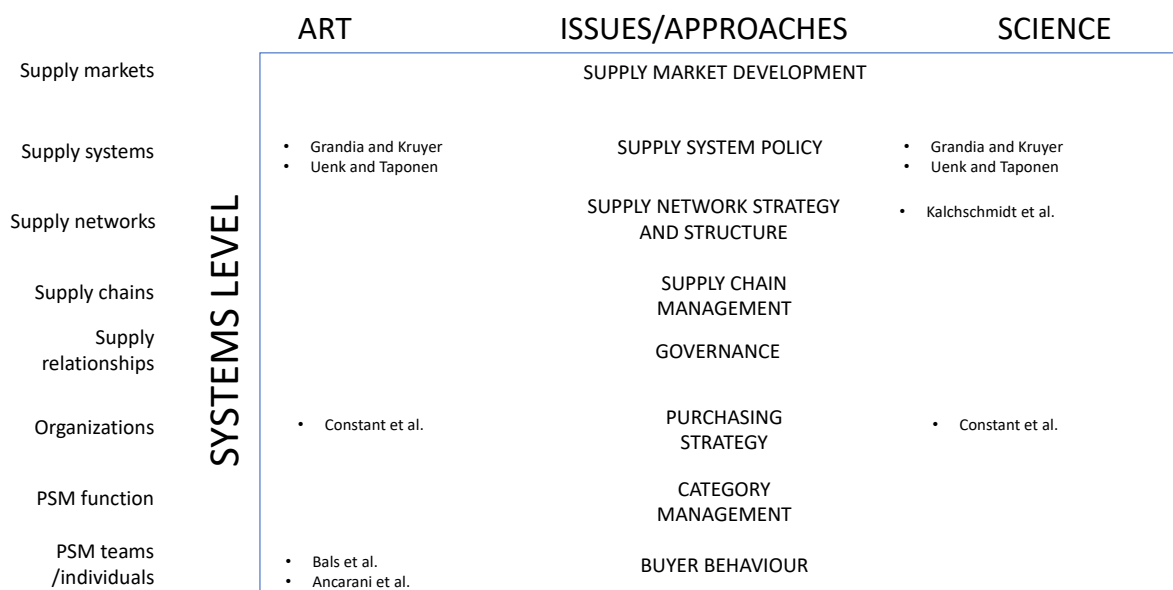


Figure 2: The papers of the special issue in the research framework

The paper by Bals et al. aims to develop a competence model of the purchasing function, to ensure the necessary sustainable purchasing and supply management competences. The theoretical background blends PSM research with educational science and organizational psychology. The authors suggest a framework based on a combination of cognitive-, social-, meta- and functional-oriented competences. Based on a structured literature review used to identify a set of competences and areas of work, the authors report on the findings from a Delphi study with 16 experts that relied on the critical incident technique. The paper has a clear focus on the PSM individual as the unit of analysis with the purpose to address new necessary competences for a successful and up-to-date approach. The focus is on individual buyer behavior, investigated from a human and personal perspective. Overall, their paper shows how a combination of different competences, both

hard and soft, is necessary. Methodologically, this paper reflects mostly the art side, identifying competences for individual PSM professionals.

The paper by Kalchschmidt et al. aims to define a methodological framework to characterise supply networks, considering the international perspectives of current global supply chains. The paper results in quantitative indices of network spatial concentration and relative proximity measures based on a non-parametric kernel density estimator. The indices are developed using an empirical method, analyzing the geographical dispersion of four emblematic supply chains of representative companies of the fashion industry. The paper focuses on supply networks as the unit of analysis, aiming to extend the concept related to supply network strategy structure. With an approach oriented to supply network mapping, the paper adopts a strong scientific approach to exploit a quantitative and scientific method to obtain a testable and objective measure of the global dispersion of the supply chain and to use these indices to support managers in taking more responsible and reliable decisions in managing supply chains.

The paper by Grandia and Kruyer applies a quantitative and structured method to investigate the implementation of sustainable practices in the specific domain of public procurement. The paper is oriented to policy makers to provide suggestions and support for the key parameters to consider in the creation of public policy. The analysis is conducted at the supply system level, with the goal to obtain insights for the definition of new supply system policies. To tackle this goal, this paper is more oriented towards the science side of procurement. The analytical and scientific method is exploited for the achievement of the results: the analysis relies on data mining on 140.000 Belgian public procurement notices over a period of five years. Through a statistical method, the main sustainability factors included in previous notices are identified. Global standards are analyzed and considered; the auditing approach might become a lens to guide future policies. In the definition of standards, there is a clear willingness to combine environmental and social sustainability goals. In addition, art oriented elements are also evident in this research. The paper is grounded in studies of society, philosophy, politics and economics and therefore social science. The authors argue that good policy makers should be creative and aspirational, but also analytical and constraining: the results show is a good combination of these two different approaches.

The paper by Ancarani et al. investigates a traditional supply chain problem - replenishment decisions in multi-echelon supply chains. This topic has been deeply investigated previously, mainly from a scientific and quantitative approach. The paper is grounded on existing models, using the multi-echelon supply chain modeled with the well-known beer game. However, this science-oriented method is complemented by an art-oriented approach as the paper considers risk aversion of individuals, moving the research unit of analysis from a traditional functional point of view to an individual perspective. The object of analysis is not the decision itself but with a very humanistic approach it is oriented to investigate the behaviors of buyers in taking these decisions, observing how purchasing and supply chain professionals interact and operate during the simulation, to include the perspective of the human intervention in the achievement of quantitative and objective decisions such as the replenishment ones.

The paper by Uenk and Taponen focuses on public sector and aims at investigating the topic of risk allocation among actors in the service industry. With a goal to support the public sector, the paper focuses at the supply systems level, the goal is to support policy makers in identifying contract types and consequent incentives. The topics of risk management and

contracting are evaluated through a quantitative and rigorous method, confirming the science approach adopted in the paper. Data of two different countries were compared, to consider the impact of legislation – a contextual variable. But the discussion of the results considers also softer elements of analysis, addressing the important combination of hard facts with characteristics of triads involved.

Finally, the paper by Constant et al. investigates the role of purchasing in firms' innovation activities. The paper focuses on the tensions between exploration and exploitation, through an ambidextrous approach, using a combination of art and science. Through an in depth qualitative case study, results of the paper identify four different types of ambidexterity to combine and complement each other. Through the research unit of analysis of the purchasing function, purchasing's contribution to strategy, exploration and exploitation to align with the organisation's business strategy is examined.

6. Conclusions

In this editorial we have taken a historical perspective to discuss a contemporary issue - the need for a combination of art and science in procurement. Inspired by the eclectic personality of Leonardo da Vinci, who was both artist (painter and designer) and scientist (engineer and anatomist), capable of combining and integrating creativity and technique, emotion and rigour, we reflected on how this approach may be transferred to our field of research and to the procurement profession. We have shown how the humanistic approach of the Renaissance was substituted by the advent of the Scientific Method, which allowed the incredible development of Science, but also led to a compartmentalization of knowledge into strictly confined and separated disciplines.

More recently, the complexity of modern-day reality has reemphasised the importance of more holistic and multi-disciplinary approaches, combining both humanistic and scientific approaches, leading to the development of System Thinking. This is what happened (in a short and simplified way) to knowledge and research; in a similar way this happened also to business management, which saw the historical development of the role of the entrepreneur (creative, innovative, eclectic) into that of the manager (specialized, rigorous, scientific), and now more recently seeing the emergence of managerial entrepreneurs or entrepreneurial managers, who combine both roles.

Focusing on procurement practice and research, a similar evolutionary path can be observed: from an original emphasis on more creative, relational, behavioural and social (i.e. 'soft') skills and competences, we have observed a transition towards more scientific, analytic, quantitative (i.e. 'hard') ones. Today the challenges and the complexity of contemporary business require both sets of skills and competences. PSM Research has followed this evolution by addressing a variety of topics and issues, at different levels of analysis, increasingly combining art and science approaches.

A conceptual framework was developed that helps in synthesising this complex picture of PSM research, showing both the hierarchical levels of analysis and the art/science dimension, with examples of different research topics and issues for each combination. We have also mapped the papers of this special issue onto this framework, as an example of how contemporary research indeed is diversified and covers the whole space of the framework, from the individual level to entire supply systems, increasingly combining both art and science approaches. Of course, the papers included in this special issue are just a few examples of contemporary PSM research, while a comprehensive mapping is beyond the scope of this editorial. Therefore our framework may be useful for future research which may aim to

provide a broader assessment of PSM literature, thus highlighting areas that are less covered and more in need of further development.

We hope this reflection may stimulate new research combining both art and science approaches in PSM, across the various levels of analysis, challenging increasingly narrowly-focused, hard science-oriented studies, trivialising PSM to the scholastic question of 'how many angels can dance on the head of a pin'. We have shown that today's procurement professionals are required to possess a broad range of competences, including both hard and soft ones. However, this is increasingly valid also at other systems levels; procurement functions, entire organizations, supply chains, networks, systems and markets also require innovation and creativity to be combined with data science and scientific rigour. We'll let Leonardo da Vinci have the last word.

"Principles for the Development of a Complete Mind: Study the science of art. Study the art of science. Develop your senses- especially learn how to see. Realize that everything connects to everything else." — **Leonardo da Vinci**

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