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CONTENT

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Alternative Manufacturing Processes (AMP) for Wind Turbine Blade Material, in Isolated Regime Based on AHP

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Abstract – The newest cutting-edge technologies in Renewable Energy Sources (RES) projects provides economic benefits for project developers, especially when installing a wind power in isolated regime. The research was focused on finding technological alternatives, using an optimal composite material for wind blades structure. In this sense, the research team made a decision based on critical analysis of today existing technologies that can provide feasible solutions. The Analytic Hierarchy Process (AHP) method provides results for choosing alternative manufacturing processes, suitable for blades structure, in isolated regime.
Keywords: collaboration, wind turbine, blade, energy, AHP, environmental.

I. INTRODUCTION

All aspects of a *Renewable Energy Sources (RES)* project life cycles include higher complexity, involves greater demand on the capabilities of project teams that need to possess appropriate experience to understand the implementation process for every activity in the project and must have special attention and knowledge to supply important components when installing a wind power in extremely weather conditions and difficult land form.

The complexity of Renewable Energy Sources projects implementation requires finding collaborative alliances between suppliers and project developers..

A collaboratively logistics system requires to be permanently dimensioned properly selected and monitored. Supply chain activities in RES project, in isolated regime implies complex activities for transportation of heavy components, finding quality raw materials, storage and materials handling [1].

Previous studies conducted by the research team in RES projects showed bottlenecks in wind power supply chain and communication difficulties between specialized teams for choosing the optimal blade material structure for a Renewable Energy Sources project, in isolated regime [2].

A challenge for wind power project developers are the obstacles that they encounter when need to strictly respect component technical specifications according to inclement weather and wind fluctuation. They also must analyze all the situations that could jeopardize the project like land form, transportation, rural roads, special equipment.

For a RES project in isolated region most common situations encountered by developers in the wind power project are [3]:

- Elaborating the project plan and how the tasks and goals will be achieved.
- What resources are needed, budget planning and scheduling deadlines for project completion?
- Obtaining necessary permits and approvals for construction work. Check and verify the installing location for power and water.
- Analysis and research of opportunities for reducing costs, by diversifying and simplifying equipment, multi-purpose of the components.
- The Financial plan funds is required, various reorganizations and restructurings are needed to complete the project in time and to achieve the desired goals.
- Tough searching suppliers that have the ability to achieve RES components with high precision.

From the point of view of supply chain, research team also identifies most common problems encountered by project developers in choosing special components for RES project in isolated regime. Related issues are presented below for blades, gearboxes, bearings, generators, cast iron and forged components, towers:

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Wind blades

A crucial component made from special composite materials that require sophisticated production techniques, global supply is dominated by independent blade maker.

Making wind turbine blade requires the execution of a sequential chain operations and time duration (this involves matrix realization, metal inserts, walls palette, pasting, filling with foam, static load testing). Some operations can be meticulous and improper organization of tasks and supply malfunction can cause delays in delivery components for implementing the project.

Gearboxes

The role of gearboxes in traditional wind turbines is to make the generator to spin much faster than the wind turbine rotor, thus creating the possibility of designing a small generator. According to the literature, in the manufacturing process of wind turbine gearboxes, achieving these gearboxes were faced with the most difficult supply due to the limited number of manufacturers adapted to market for wind power [5].

The most common problems are caused by deficiency of large bearings and frequent defects registered by gearboxes of wind turbines.

Bearings

Gearbox and main shaft of the traditional wind turbine utilizes large bearings, which are used on larger scale in heavy industry. Given that installing projects for wind turbines represent just an isolated activity segment for bearings large suppliers, specific deficits were recorded in the procurement process for manufacturing turbines.

Generators

The generator converts the mechanical energy into electricity. The generators used in wind turbines are slightly different from the usual, because the generator has the wind turbine rotor for power supply, which ensures very fluctuating mechanical power (torque). In the wind industry are already quite many specialized providers for such dedicated generators, so the supply does not suffer difficulties for this component [6].

Cast iron and forged components

This represents the highlights pieces, with which they configured the main frames used to support nacelle and rotor hub and main shaft, which connects the rotor gearbox. Similar situation encountered in large bearings, the market was again affected by high levels of activity in the heavy industry sector, with an increasing demand for both steel and wrought iron [7].

Towers

Although in the major wind farms, most turbine towers are made of rolled steel, currently tends to redirection producers to use concrete as a cheaper alternative. Manufacturing a wind turbine tower is an increasingly complex technical process and expertise from the design phase is more clear and available for alternative solutions than for other components.

Knowing these aspects in the RES supply chain can affect the collaborative behavior of suppliers and also can provide potential risks for quality and inventory. These risks affect the proper functioning of informational processes, materials and products between different parts of the supply chain in collaboration with other manufacturers and suppliers in RES.

The most difficult situation for project developers in implementation of the wind power project is the fact that when they purchase components through public procurement for a RES project in isolated regime. For public procurement project managers, must select those suppliers who fulfils all the technical requirements imposed by the isolated region. This process is very complex and time consuming and can made the project to surpass the installation time.

In order to identify wind blade specialized supplier in choosing optimal wind turbine blades for a RES project in isolated regime, the research team, propose a multi-criteria analysis method, that can provide feasible technical solutions for this type of project when are purchase components through public procurement.

Also, for type of project specialists' teams have been put in difficult situations to harmonize different equipment to install the components for wind turbine in the location and complete some additional activities like:

- Finding quality raw materials;
- Select an optimal construction and foundation;
- Strictly assembly process;
- Special storage handling.

In this scenario, a good collaboration between specialists' teams was a must because the isolated region characteristics had relative disadvantages for extremely weather conditions and landform, which made the wind turbine difficult to implement. The characteristics of isolated region has implied a smaller number of panels, and a power reduction of the wind generator. RES project in isolated region with extremely weather conditions and landform has required to use a wind turbine less than 1.0 MW.

The research was focused on finding technological alternatives, suitable for wind blades structure, in isolated region. Given the harsh weather conditions and wind speed, necessary wind blades were designed with great precision. Thus, it was required a multidisciplinary collaboration in decision making, to achieve an aerodynamic model and a structural model for wind blades.

The design process involved a structural model of the blade, to obtain a reduction in blade weight, which corresponds to the power of the wind turbine, less than 1 MW, using an optimal composite material structure. Based on the rare situation of the isolated

regime, namely resulting solution of the designing process, the research presented in this paper offer a decision based on critical analysis of today existing technologies that can provide feasible solutions for wind blade structure adapting to isolated regime.

II. WIND BLADE STRUCTURE

Blades are placed in category of sensitive aerodynamic devices. Due to the fact that blades have a special design, these will not perform at full capacity if damaged, therefore, it is important to handle carefully when installing at the wind farm site. Back in the days in wind energy industry, large wind turbine blades have start to be manufactured from steel, aluminum and wood. Over the time, blades made from steel and aluminum has proven to be inefficient because of the overweight that has cause a poor functionality and energy waste. Meanwhile, manufacturers have turn their attention to composite materials, usually fiberglass and carbon fiber. Carbon fiber material provides the highest strength-to-weight ratio and stiffness, but has not been widely used because of his high costs. Typical reinforcement used in composite materials are stiff, strong and lightweight fibers such as e-glass fibers (good specific strength, low specific stiffness, relatively inexpensive) and carbon fibers (high specific strength and stiffness, expensive).

A good performance for wind blades implies a special manufacturing process, higher resin properties, quality fiber material, a higher level of automation, and a consistent process reduction in blade weight. The main objective of the manufacturing process is to reduce blade weight both on the blade and also on the rotor blade. Manufacturing methods have consequence on blade life. Blades manufacturing process and structure assembly represent a crucial process that required sophisticated production techniques for wind blades. In this case was obtained several alternative manufacturing processes (AMP): resin infusion, automated preform, thermoplastic resins, fully integrated structures and separately-cured spar structure (Figure 1). These AMP through Automated Preform Manufacturing represent a modern option to wind industry [4].

III. MULTI-CRITERIA DECISION MAKING

To achieve optimal selection for a wind blade structure in a RES project in isolated regime a Multi-Criteria Decision Making (MCDM) methods provide a logical framework to investigate, analyze, and solve such problems: Vargas (2010) offers schematic approach for the AHP method [9]:

- Provide an effective structure in decision-making process;
- Shows objectives which decision maker has identified;
- Measurable evaluation criteria of objectives are established;
- Provides several ways of aggregating data concerning criteria for obtaining indicators (scores) of alternatives performance;
- Helps to maintain decision makers thinking models by deriving the relative weight of each component;
- It is assigned a numerical value to each alternative of the problem;
- Through mathematical calculation is chosen the optimal alternative.

One of the MCDM methods it is represented by ***Analytic Hierarchy Process Method***.

The algorithm AHP is done in six stages:

1. Hierarchical scheme composition of the problem that need to be analyzed. (Figure 2) In this phase it is presented fundamental purpose of the problem to be analyzed. Decision criteria are identified. Depending on the preferences of the analyst alternatives are presented and ranked by the decision. Utilization of AHP method involves the decision tree decomposition into criteria and alternatives. (Figure 2)

2. Establish relative weights by comparing them in combinations of two. The relative weights are based on a numerical scale from 1 to 9 through Saaty scale followed by subjective evaluation of the decision-maker comparisons are made in pairs. By comparison is obtained the degrees of importance of a criterion to each other (Table 1) [8].

3. The relative prioritization of the criteria is obtained by comparing criteria two by two depending on the decision criterion, in order to rank them.

4. Pairwise comparison is made for criteria gives them a global priority. Global priority for each decision criteria is determined by the result of multiplying each priority vector for each criterion on the second level of the decisional tree.

Table 1. Relative importance through Saaty scale [8]

#	***Verbal menaing for risk factor evaluation***	***Verbal menaing for alternative evaluation***
1	Equally important	Equally prefered
2	Equally to moderately more important	Equally to moderately prefered
3	Moderately more important	Moderately prefered
4	Moderately to strongly more important	Moderately to strongly prefered
5	Strongly more important	Strongly prefered
6	Strongly to very strongly more important	Strongly to very strongly prefered
7	Very strongly more important	Very strongly prefered
8	Very strongly to extremly more important	Very strongly to extremly prefered
9	Extremly more important	Extremly prefered

5. Performance matrix is achieved by calculating the relative prioritization of the alternative for each criterion. In this step is necessary to assess alternatives relative weights from the third level of the hierarchy, the process is similar to that has been used in criteria group for the purpose decision-making. This process is executed as the previous step, but the difference does that this step is performed assessment of each alternative beside each criterion.

6. The final decision is obtained by choosing alternative priority with maximum points.

IV. ALTERNATIVE MANUFACTURING PROCESSES (AMP)

It is known that infusion processes have the potential for low-cost, high-quality production of wind turbine blades, with the added benefit of having low volatile emissions. Additional benefits may be possible if the infusion process is combined with automated preforming technologies [4].

Automated preform manufacturing have advantage to reduced hand labor, improve quality of fiber placement and orientation, and reduce production cycle times. The research team indicated the main criteria through Automated Preform Manufacturing: **Stitched Hybrid Fabrics, Cut-and-Sew Preforming, 3-D Woven Preforms, 3-D Braided Preforms and Oriented Sprayed-Fiber Preforms** (Table 2 and Figure 1).

Automated Preform Manufacturing processes for blade structure indicated that all preforms are assumed to be a combination of carbon / fiberglass material showing different benefits and limitation for each criterion.

After the information's were obtained in Tab.1 the research team must to take into account what material composite structure for wind blade has an automated preform manufacturing that is relevance for the RES project, in isolated regime. Analyze the options presented in Table 2 indicates that Cut-and-Sew Preforming can reduce production cycle times but is not very reliable and could not easily be adapted. This is the reason way Cut-and-Sew preforming would not be compered due to the lack of information for delivery time and difficulty rate.

Stitched Hybrid Fabrics is somewhat more expensive, have a higher rate to operate, and it is very reliable but not very adaptable. 3-D Woven Preforms is a little less reliable than Stitched Hybrid Fabrics due to delivery time but is claimed by the manufacturer to have a wide range of alternative uses. 3-D Braided Preforms and Oriented Sprayed-Fiber Preforms have the same difficulty rate but different benefits [4].

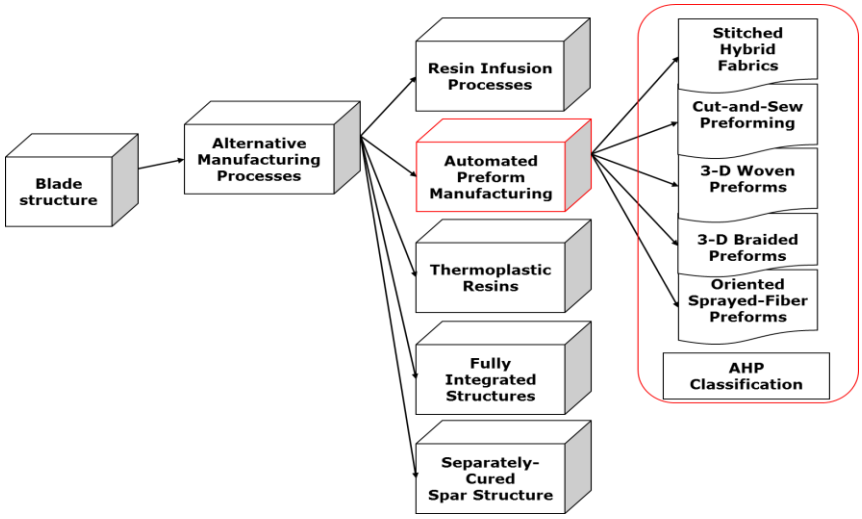

Fig. 1. Blades alternative manufacturing processes [1]

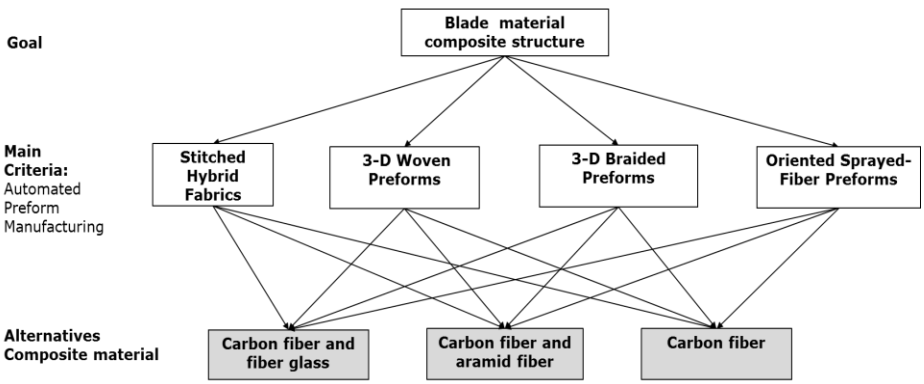

Fig. 2. Blades structure [8]

Table 2. Blade material composite [4]

APM for blade structure	*Benefits*	*Limitations*	*Material combination*	*Delivery time*	*Difficulty rate*
Stitched Hybrid Fabrics	carbon fiber contributes high tensile compressive strength and stiffness and reduces the density, while glass reduces the cost	increased cost and weight of the spar cap structure	unidirectional carbon fibers with e-glass tri-axial fabric	3 weeks	Higher
Cut-and-Sew Preforming	combination of unidirectional or multiaxial fabrics and as a result can be used to reduce production cycle times	not yet identified a manufacturer to evaluate the potential of cut-and sew preforming for application to wind turbine blades	N/A	N/A	N/A
3-D Woven Preforms	higher stability for fiber placement and laminates have higher resistance to crack propagation	considered unlikely to be cost-effective and more difficult to infuse with resin	carbon in the warp direction and e-glass in the fill and axis directions	4 weeks	Very higher
3-D Braided Preforms	manufacture of small (50 to 100 kW) wind turbine blades achieving the objectives for reduction of labor costs, less material costs and improved blade quality and reliability	braiding processes considered appear non-competitive for manufacturing large wind turbine blade spar cap structure	unidirectional carbon fibers	2 weeks	Moderate
Oriented Sprayed-Fiber Preforms	low hand labor costs, control of fiber placement, control of fiber orientation, high level of consistency, capability to produce complex geometrical shapes, low waste of raw materials, and decreased cycle times	large wind turbine blades	carbon and fibers	2 weeks	Moderate

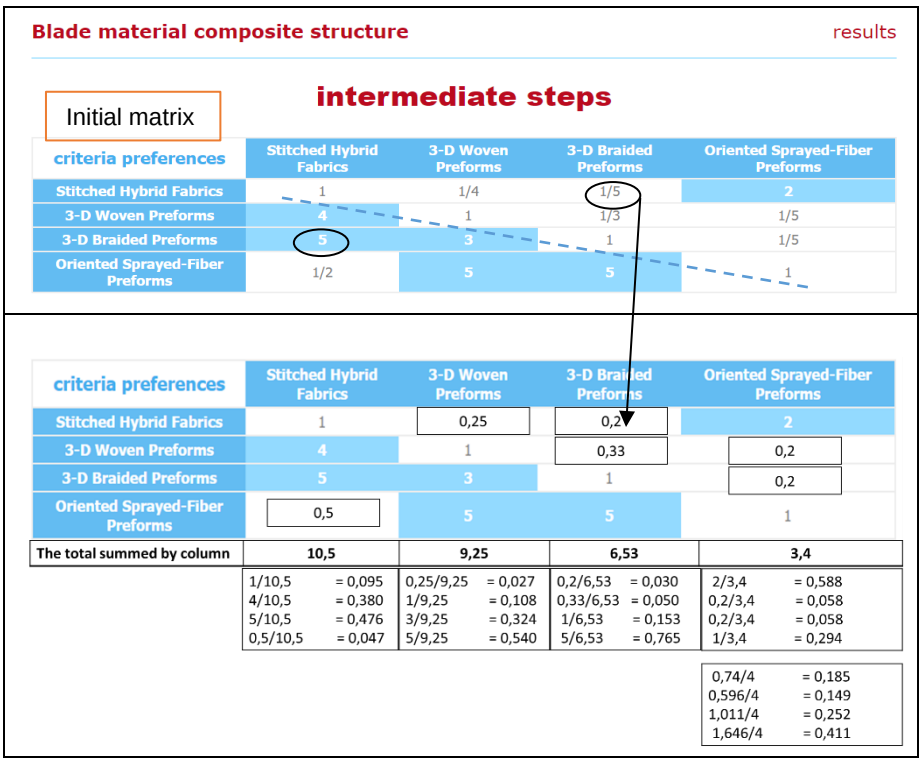

Fig. 3. Initial matrix for criteria

V. AHP RESULTS

Automated preform oriented sprayed fiber ofers low hand labor costs, control of fiber placement, control of fiber orientation, high level of consistency, capability to produce complex geometrical shapes, low waste of raw materials, and decreased cycle times.

A decision hierarchy is configured through a graphical representation of the goal, the main **criteria,** (*Stitched Hybrid Fabrics, Cut-and-Sew Preforming, 3-D Woven Preforms, 3-D Braided Preforms and Oriented Sprayed-Fiber Preforms*) and **alternatives** (*Carbon fiber and fiber glass, Carbon fiber and Carbon fiber and aramid fiber*). This hierarchic frame and decomposition represent a succinct summary of the decision problem.

In order to have a clear evidence it was employed a numerical rating to 1-9 and reciprocal rating of the Saaty scale [7]. Using Saaty scale, a basic, but very reasonable, assumption is that if criteria 3-D Braided Preforms have a ***Strong importance*** than criteria Stitched Hybrid Fabrics and his value is 5, then Stitched Hybrid Fabrics is ***Less important*** and his value is 1/5.

3-D Braided Preforms is focused on manufacture of small wind turbine blades (50 to 100 kW) achieving the objectives for reduction of labor costs, less material costs and improved blade quality and reliability. Criteria preferences are designed through a matrix noted with numerical value from Saaty scale.

Criteria Stitched Hybrid Fabrics is ***Less important*** compared with 3-D Braided Preforms and his reciprocal value is 1/5, namely 0.2 and the same calculation are done for all reciprocal criteria. It is provided an initial matrix for pairwise comparisons in which the principal diagonal contains entries of 1, as each criteria is as important as itself (Figure 3).

In order to interpret and give relative weights to each criterion, it is necessary to normalize the previous comparison matrix. Stitched Hybrid Fabrics has a total summed by column a value of 10.5 (1+4+5+0.5). The normalization is made by dividing each table value by the total summed in column value, namely 1/10.5, 4/10.5, 5/10.5 and 0.5/10.5.

Criteria preferences for Stitched Hybrid Fabrics has a value of 0.185 and has been calculated in line summing the values (0.095+0.027+0.030+0.588) and divided by 4 (represent the number of criteria) (as presented in Figure 3).

Final result provided by AHP algorithm are obtained and criteria importance has indicated **Oriented Sprayed Fiber Preforms**.

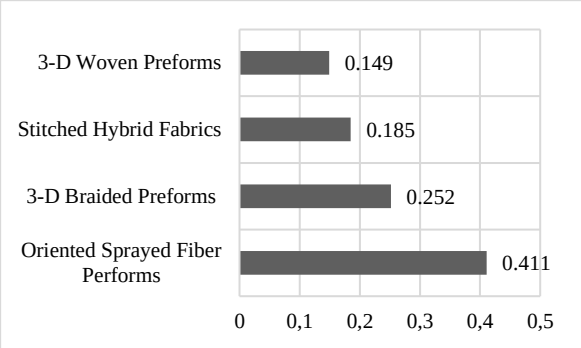

Fig. 4. Criteria importance

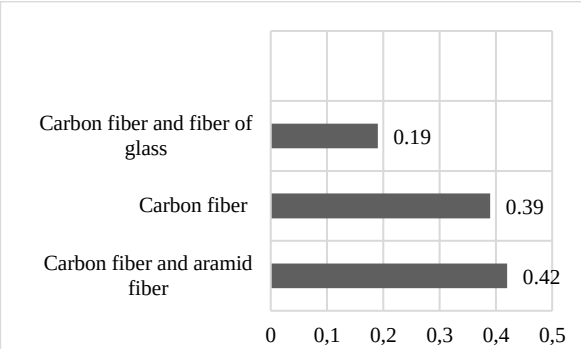

Fig. 5. Alternatives importance

An impediment using this preform made by the manufacturer was that this type is more suitable for large wind turbine and in this RES project in isolated regime the wind turbine used was less than 1.0 MW power.

Second option given by AHP method was the **3-D Braided Preforms** because it is specialize to manufacture small (50 to 100 kW) wind turbine blades, but also achieving the objectives for reduction of labor costs, less material costs and improved blade quality and reliability (Figure 4).

Using AHP algorithm identified the optimal combination of composite blade structure so as to meet the unique technical parameters specific for RES project. ***The alternative provided by AHP algorithm indicated using a hybrid composite material for wind blades, respectively carbon fiber and aramid fiber (0.420)(Figure 5)***

VI. CONCLUSION

This ***hybrid composite material*** offers economic and environmental advantages for assembling a wind turbine in isolated regime. Given the harsh weather conditions and wind speed, the 3-D Braided Preforms for wind blades can ensure a reliable alternative.

Based on AHP method, decision obtained for 3-D Braided Preforms provide feasible solutions. RES projects in isolated regime are a compromise solution, but implementation on such projects provides local

energy needs in isolated locations. Even in this case these represent an important way for generating green energy which in a visible manner sustain the strategy to achieve Romania's mandatory targets within the EU strategy 20/20

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Some Considerations on the Smart City concept. From Necessity to Implementation Challenges

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Abstract – Today, urbanization phenomenon is a reality. Cities are urged to find new solutions for managing their assets in order to prosper, otherwise face decline. This state of facts and necessities require new technologies, new legislation, new managerial approaches and a good understanding of mass psychology. Simultaneously, in the actual era of globalization and scarce resources management, cities must collaborate through efficient information and communication platforms in order to specialize themselves, on the basis of a common strategy. All these challenges have to be studied and addressed for each city, separately and contextually, in order to create the smart cities of 21st century. The aim of the article is to make an overview of the smart city concept development and to underline important aspects, statistics and points of view for its implementation.
Keywords: urbanization, globalization, scarce resources, collaboration, smart specialization, smart cities.

I. INTRODUCTION

A clear and general accepted definition of smart city still lacks, not only in the academic studies, but also in empirical applications of smart concepts and projects [33]. Furthermore, the actual and relevant references research shows what follows [5, 7]:

- "The smart city concept is used to identify a large spectrum of heterogeneous solutions and city programs, involving different types of technologies and aiming to reach a very large set of different and not well-defined goals;
- In the meantime, several different words are used to define similar projects and solutions, even if each of them could easily be attributed to the idea of smart city. For example: wired city, intelligent city, digital city, technocity, and so on. The similarities and the differences between all these "cities" are generally not explained".

According to [7], the main reason of this confusion is that *smart city is not a top-down phenomenon, but a bottom-up one*. The top-down process arises from a well-defined strategic vision of the smart city and it is developed applying the government rules and policies, to reach shared goals stated from the beginning. In the same time, the smart city idea arises from the application of technology to urban problems.

Smart city defines an urban development vision which integrates multiple last-generation technologies in a secure manner, by having the information and communication technology (ICT) industries as basis, in order to manage the city assets and improve the quality of life and the its residents activities, regardless whether they are citizens, private companies, public institutions or non-government organizations [24].

The worldwide trend is to concentrate more and more population in the urban centers, as a consequence of the opportunities, resources and comfort that could be found in these areas. It is expected that the urban population will reach 65% of the total world population by 2050 [26]. Furthermore, there are countries where metropolitan administrations and governance have become more important than regional administrations, managing to directly and indirectly govern the destinies of the communities in the area under their influence.

In previous studies, the adjective "smart" also referred to the government of a city and its capacity to generate innovation in the way services and communication are delivered to the local population. Therefore, a growing concern naturally exists with respect to urban and smart cities development, given the increasing managing challenges and the pressures they are subject to, including the related risks and the rising impact of human or automated decisions.

Table 1 [26] provides an overview of the multitude of domains addressed in the smart city literature, which indicate the many facets of the urban development. The domains can be classified as *hard* or *soft*, in relation to

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the importance that the ICT systems have as key enabling technologies.

"Specifically, hard domains refer to office and residential buildings, energy grids, natural resources, energy and water management, waste management, environment, transport, mobility and logistics. In these settings, an improvement in sustainability relies on the deployment of ICT systems, along with the introduction of appropriate policy interventions and urban planning. In other words, hard domains are the city settings in which the vision of a city that senses and acts can be the most applicable, thanks to the use of sensors, wireless technologies and software solutions to handle *big data"* [26].

Table 1. Literature review on the domain of smart city concept and approach (extended from [26])

Prevalence of investments related to the *hard* domains:		
Domain	***Main objectives***	***References***
Energy grids	Automated grids that employ ICT to deliver energy and enable information exchange about consumption between providers and users, with the aim of reducing costs and increasing reliability and transparency of energy supply systems.	[6, 8, 21, 29]
Public lighting, natural resources, and water management	Managing public lighting and natural resources. Exploiting renewable resources such as heat, solar, cooling, water, and wind power.	[1, 8, 10, 24, 30, 32]
Waste management	Applying innovations in order to effectively manage the waste generated by people, businesses, and city services. It includes waste collection, disposal, recycling, and recovery	[1]
Environment	Using technology to protect and better manage environmental resources and related infrastructure, with the ultimate goal of increasing sustainability. It includes pollution control.	[2, 6, 19, 24, 31]
Transport, mobility, and logistics	Optimizing logistics and transportation in urban areas by taking into account traffic conditions and energy consumption. Providing users with dynamic and multi-modal information for traffic and transport efficiency. Assuring sustainable public transportation by means of environmental-friendly fuels and innovative propulsion systems.	[2, 5, 8, 10, 20, 23, 24, 29, 30, 32, 34]
Office and residential buildings	Adopting sustainable building technologies to create living and working environments with reduced resources. Adapting or retrofitting existing structures to gain energy and water efficiency	[1, 29, 30, 34]
Healthcare	Using ICT and remote assistance to prevent and diagnose diseases, and deliver the healthcare service. Providing all citizens with access to an efficient healthcare system characterized by adequate facilities and services.	[1, 2, 8, 10, 24, 34]
Public security	Helping public organizations to protect citizens‟ integrity and their goods. It includes the use of ICTs to feed real time information to fire and police departments.	[1, 10, 24, 34]
Prevalence of investments related to the *soft* domains:		
Education and culture	Capitalizing system education policy, creating more opportunities for students and teachers using ICT tools. Promoting cultural events and motivating people participation. Managing entertainment, tourism, and hospitality.	[1, 10, 21, 24, 34]
Social inclusion and welfare	Making tools available to reduce barriers in social learning and participation, improving the quality of life, especially for the elder and disabled. Implementing social policies to attract and retain talented people.	[2, 3, 5, 6, 8, 14, 21, 32]
Public administration and (e-) government	Promoting digitized public administration, e-ballots and ICT-based transparency of government activities in order to enhance citizens' empowerment and involvement in public management.	[1, 3, 5, 6, 8, 10, 14, 27, 29, 30, 32, 34]
Economy	Facilitating innovation, entrepreneurship and integrating the city in national and global markets.	[3, 5, 6, 8, 14, 21, 32]

"The soft domains include areas such as education, culture, policies that foster entrepreneurship, innovation and social inclusion, as well as communication between the local public administrations and the citizens (mainly supported by e-government solutions). In these areas, ICT has a more limited role and is not necessarily aimed at processing and integrating real-time information. This is the case of education, where processes are not based to any great extent on handling transactions. In other cases, such as the one of innovation and social inclusion policies, smart city initiatives are not characterized by new technology deployment but rather by public interventions aimed at creating the right societal and institutional conditions (e.g. incentives, ad-hoc organizational bodies, etc.). In the case of culture, public involvement could be aimed at improving the exploitation and attractiveness of a city's cultural heritage. In the case of policies that foster human capital and innovation capabilities, the role of the local policies in creating the right institutional condition could mean, for example, the establishment and support of local incubators for hi-tech start-ups and their connection to global-scaled

innovation systems. Fields such as healthcare and public safety can be positioned somewhere in - between hard and soft domains, as smart city interventions in these settings can be characterized by the deployment of sensors and wireless technologies (e.g. the use of such technologies to automate the remote assistance of patients outside hospitals) or by the deployment of practices and campaigns aimed at creating social values" [26].

In the context described by the brief presented literature review, the aim of this article is to make an overview of the smart city concept development and to underline important aspects, statistics and points of view for the implementation. In the followings, identified issues and approaches for implementing the smart city concept will be presented.

II. PROBLEMATICS AND APPROACHES

The challenges of developing a smart city are many and depend on a substantial variety of factors, fields and specializations: (macro) economics, sociology, engineering (ITC segment having a high importance), management, real time adaptability (as a component covered by the general systems theory) and so on. As seen in Figure 1, smart city concept is considered a very complex conglomeration of systems and levers that must be organized and coordinated so that the overall situation at that time, legislation, technology, feasibility and the acceptability of the community to be overlapped to the biggest extent possible, by finding the common denominators for reaching greatest positive effects with small efforts.

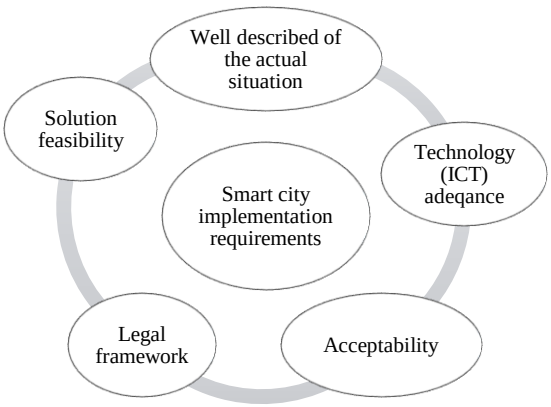

Fig 1. Five parameters to be considered for implementing the Smart Cities solutions

Moreover, the physical and virtual (digital) interconnecting of the cities in this globalization and regionalization era is a priority for their survival and prosperous development. It is well known that some cities have fallen on a descending trend after they had been decoupled from main transportation networks, which had strong negative implications in terms of industrial, commercial and social development.

In the context of the *necessity to interconnect the cities* a new problematic arises, that of smart specialization. This means that each city should capitalize its strong-points in correlation with their potential and resources in the territorial, economic and social existing constellation. A desired principle to be applied in the era of globalization, increasingly scarce resources and ever growing dynamics in all fields is the so-called "*low hanging fruits*", so that the added value to be generated with minimum effort in a short time and with minimum risk.

And, extrapolating this previously given principle, it must be underlined that the attention for the aspects of environmental protection and sustainable development will be crucial for the good management of our planet as a whole and of the communities in which we live, in order not to reach during next dozens of years *the point of no return* on which we are warned by worldwide institutes with forecast expertise.

Developing a smart city will increasingly depend on aligning and integrating the new world of Internet of Things (IoT) in the complex life of the city. This concept defines the network, in exponential expansion worldwide, of smart objects that communicate with each other and which automate, facilitate the activities and improve the living conditions (see Figure 2, 3, 4, 5) [11]. The explosion of smart objects is determined by globalization, fierce competitiveness in the economy, the creation of free software and "open source" applications, which influences more and more the individual and collective mentality, in terms of private and professional life.

The diversity of Internet of Things is practically infinite, as any object of interest can be operated and controlled in the future through the network (Figure 3) [12].

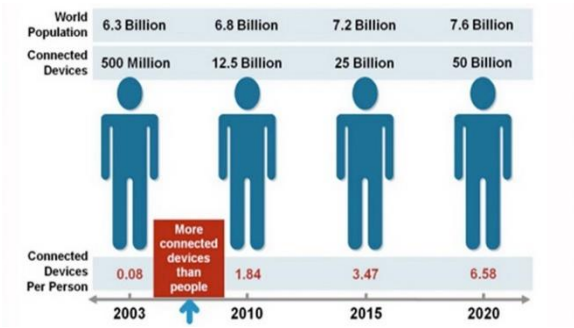

Fig. 2. Estimation of connected devices and population statistics [11]

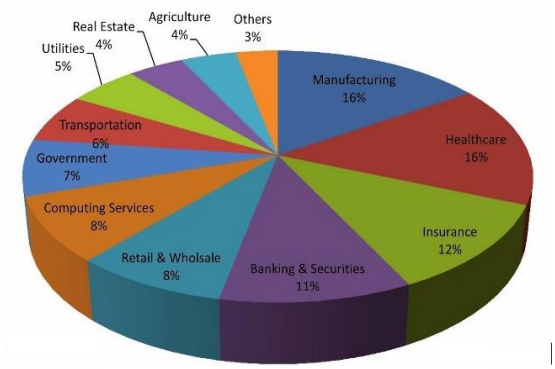

Fig. 3. Estimated IoT added value by 2020 - $ 1.9 Trillion [12]

In all these concerns and approaches for implementing a smart city there is the need to have a good balance and a set of priorities, established through thorough analysis and with the involvement of the civil society and business environment, which are very important components for the long-term success of projects which are initiated and implemented by public administrations. If these two important factors will not be involved, undoubtedly this will lead to the decline of these urban areas, because of the migration of individuals and companies to other more favorable areas, in the context of high mobility which is characteristic to the modern world, namely in the European Union.

Investments needed to be made in order to transform the city into an intelligent one are very high and diverse. Therefore, hiring the business environment in various forms of collaboration, such as, for example, public-private partnerships, is essential. Businesses can faster stimulate and guide the conversion of cities into smart cities, according to their own economic interests, which must be linked in a "win-win" situation with the interests of the local community (Figure 3, 4, 7) [4, 15, 16, 17].

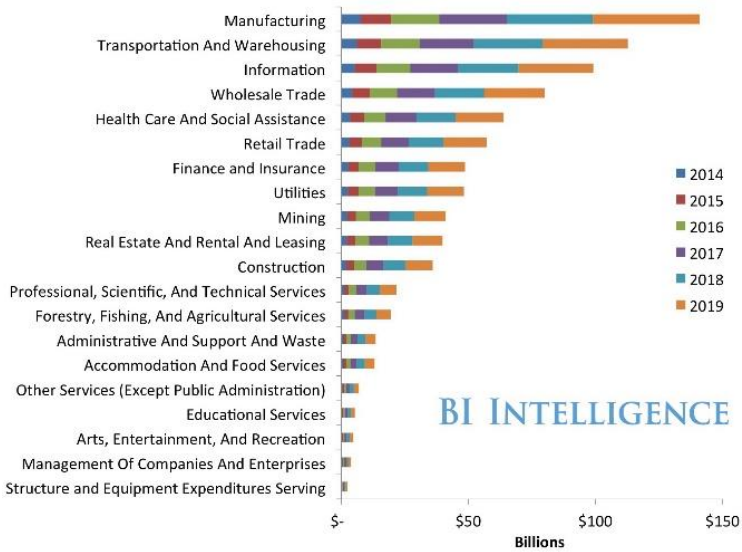

Fig. 4. Estimated investments in IoT solutions by industry [15]

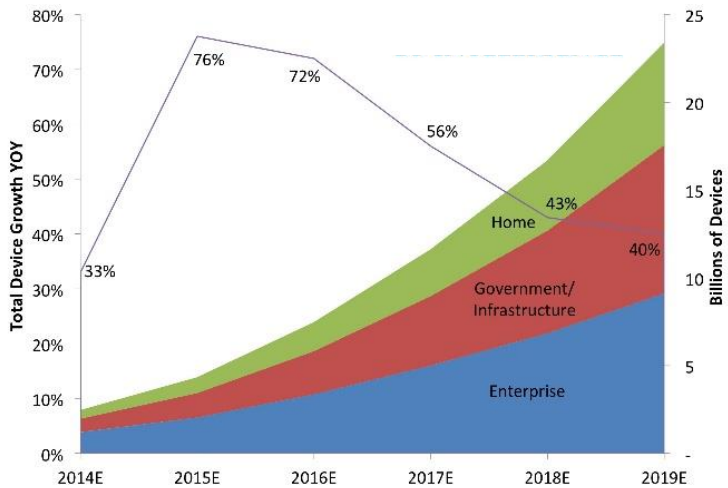

Fig. 5. Estimated number of installed IoT devices by sector [16]

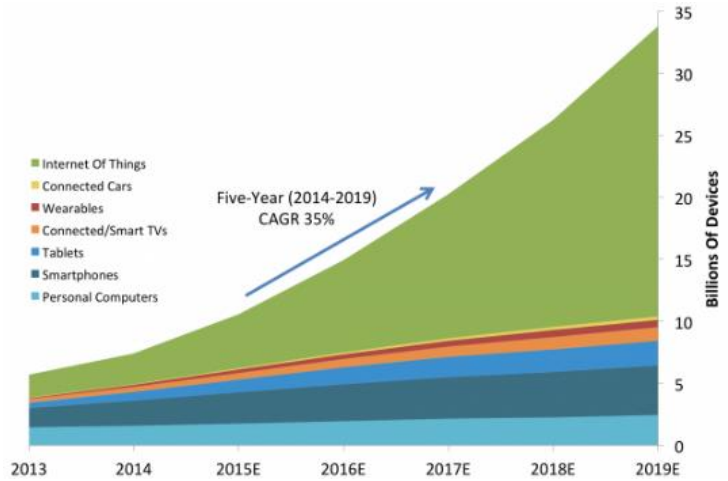

Fig. 6. Estimated number of devices in IoT by type [17]

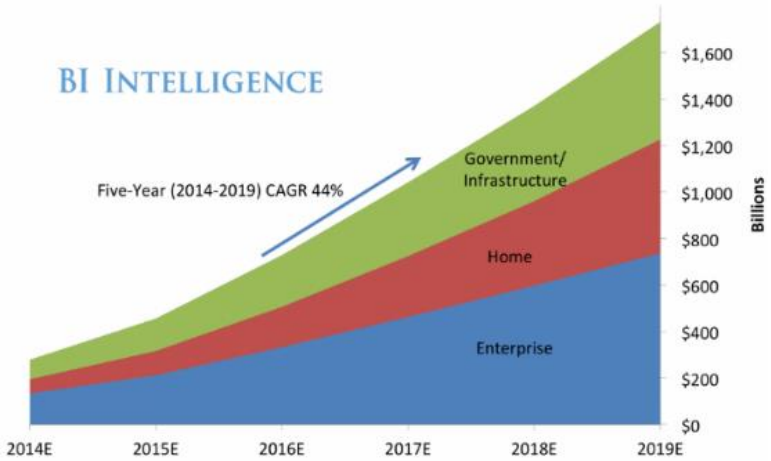

Fig. 7. Estimated IoT added value by sector [4]

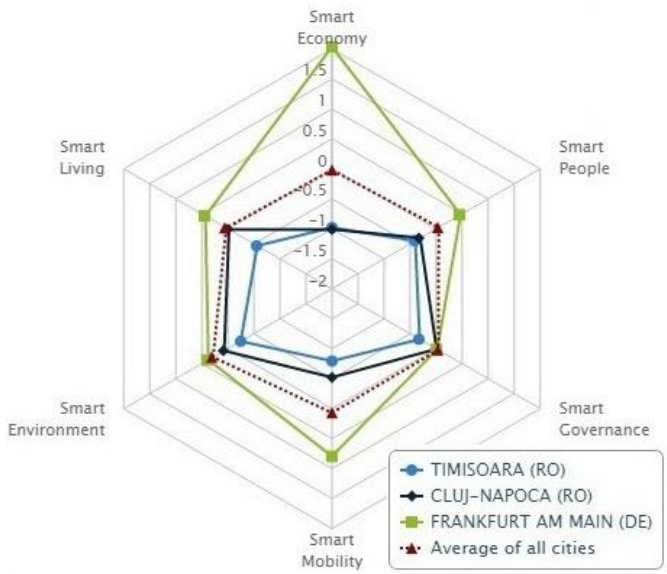

Fig. 8. Benchmarking of Smart Cities[5]

A city can be automated and improved almost indefinitely, within the limits of available resources and community interests, while maintaining respect for the environment, tradition, identity and posterity. In addition, the ability to innovate and to bring together individual solutions into aggregates (e.g. public lamp

[5] Application European Smart Cities 4.0 (2015). Retrieved from www.smart-cities.eu/?cid=5&city=47&ver=4

posts with integrated solutions for telecommunications, video surveillance and monitoring of pollution) will significantly reduce the cost of implementation (Figure 4) [4, 17].

The question is which are the mandatory minimal systems to be implemented and integrated into the functioning of a city for the city to be considered intelligent, so that added value, services, quality of life, security, safety, cost reduction and sustainability to be at the desired levels?

Four pillars are mentioned in the specialty literature, to be managed by the entities that implement smart cities: institutional, infrastructural (physical), economic and social.

- The institutional pillar concerns the improvement of public administration functions and the active and harmonized participation of citizens in local governance.
- The infrastructural pillar serves the traffic management (e.g. safety, fluidization and parking), public adaptable and renewable lighting, quality and gratuity of telecommunications, existence of the monitoring and alerting systems, streamlined collecting of waste, proper irrigation of green spaces, automated reading of utilities consumption, pollution monitoring of all kinds etc.
- The social pillar manages the modernization of education (e.g. digital systems), medicine (e.g. telemedicine), sport, leisure and so on, by using the top technologies.
- The economic pillar aims at increasing the performance in incubating start-up companies, developing financial hubs, creating digital systems for trade and business cooperation, etc. A good analysis of the described pillars is shown in Figure 8.

There are also other perspectives recognized in modeling a smart city. One of the most common is the one that defines the following levels for smart development: economy, citizens, administration, mobility, environment and living conditions.

There is be observed that to these pillars a new *transversal pillar*, namely the capacity to adapt and respond in real time, should be added. The argument for this is that, at present, scientists have not yet identified and mastered all algorithms that function in nature and mankind. This aspect justifies a new pillar, which covers all the other pillars for the achievement at the outset of adaptive and intelligent systems, capable of learning on the fly the patterns in which a community operates, patterns that cannot be defined by simple mathematical models.

However, these adaptive systems will be able, over time, to calculate and determine sophisticated algorithms that function in the outside world, as the "*Eureqa device*" developed by Cornell University, and then they will improve their performance accordingly. Such an adaptive system with its own reaction under continuous improvement will be based on a subsystem of data accumulation in absolute and relative terms, as well as information on trends of observed phenomena, different aspects which are seemingly chaotic, effects of overlapping causes, quantifiable behavior and feedback of users, influence of weather etc. (Figure 9) [18].

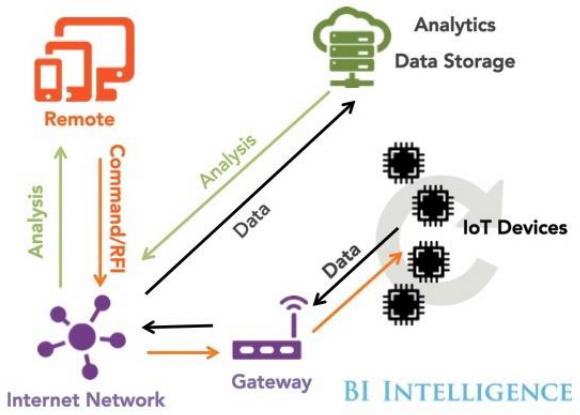

Fig. 9. Internet of Things ecosystem [18]

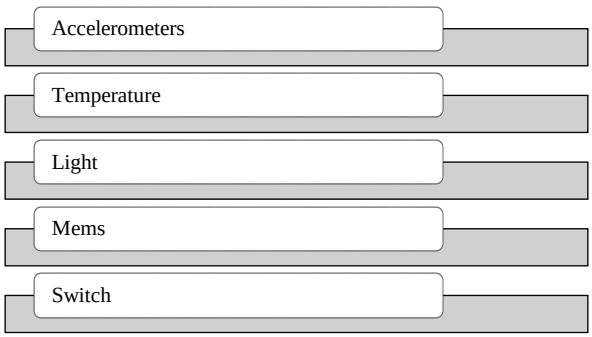

Fig. 10. Sensor types [22]

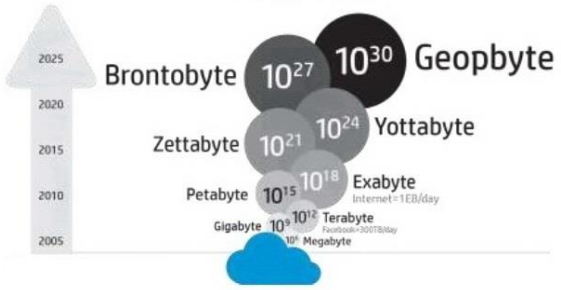

Fig. 11. Estimation of data explosion [28]

This adaptability is based and will rely on a network of sensors that are already part of the systems and smart cities of today (Figure 10). Furthermore, this network of sensors will become more complex, reliable and accurate, so that they can manage all data and information which are necessary to operate at the desired parameters, including the critical situations, such as emergencies and natural or artificial disasters. These sensors will be complemented by other subsystems and the direct feedback of citizens and human operators, feedback that probably will not be

substituted by any other automatic mechanism in the following decades [22].

These data collected by sensors are stored, processed, summarized, correlated and interpreted in certain schemes, so as to support the decision making which is most appropriate by human or automatic operators, which in turn are positioned in a collaborative network of the smart city. These data can be structured (i.e. data that can be recorded in data files) or unstructured (photos, video, social media, emails etc.) [28].

The challenges in this field are multiple, starting from the reliable storage capacity in large amounts and in all circumstances, processing capacity and information security to the information accuracy and models for interpretation and decision making (in meeting the estimation of data explosion shown in Figure 11) [28].

It is this concentration of information and human or automated decisions that increase the risk of cyber-attacks and terrorism, which leads to the need to secure better these control mechanisms operating in smart cities. The systems vulnerability with regard to the physical infrastructure (electrical, medical, for telecommunications, transport, water supply etc.), economic and even social (for automation of specific services) is not a permitted option and can conduct to chaos in few moments, given that citizens will lose to a certain extent their ability to adapt and react rapidly because of the automated systems which they have become accustomed (see Figure 12) [25].

As shown in Table 2, in this new reality of smart cities that are already or are to become metropolises, an issue will be the privacy and the right to privacy of citizens, who will live and work in an environment populated by millions of sensors, cameras, user identification tools etc. [13].

In this context a question arises: what percentage of the population will be willing to give up some of its own privacy to earn additional performance, comfort and safety, as well as what are the citizens willing to give up and what not. Such sociological and psychological matters will have to be weighed very well, before taking any steps to transform the city or interfering in a situation punctual [13].

Table 2. Connected things installed in Smart Cities (Millions) [13]

Smart city subcategory	***2015***	***2016***	***2017***	***2018***
Healthcare	3.4	5.3	8.4	13.4
Public Services	78.6	103.6	133.1	167.4
Smart Commercial Building	377.3	518.1	733.7	1,064.8
Smart Homes	174.3	339.1	621.8	1,073.7
Transport	276.9	347.5	429.2	517.4
Utilities	260.6	314.0	380.6	463.5
Others	8.6	13.3	20.8	32.3
Total	1,179.7	1,1641.0	2,327.7	3,332.5

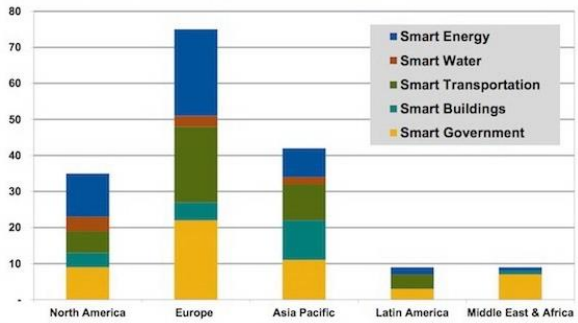

Fig. 12. Smart city projects by region and primary industry sector, world markets: 2013 [25]

Furthermore, in terms of information security and psychology, a critical aspect to be defined with respect to the key management instruments of smart cities is the responsibility of decision and action, no matter human or automatic, because a single command, such as a button press, could trigger actions and chain reactions with large negative effects in case of errors or bad intentions, whether judgment or calculation. This will require the people entrusted with important responsibilities to undergo regular psychological tests, just as the actuation devices will be equipped with dual control mechanisms (e.g. interlocking) and remote intervention mechanisms. And this all the more that the existence of adaptive systems which learn by themselves in time will lead to the development of artificial forms of consciousness, which -at one time- could take different decisions to the decisions acceptable to humans.

The issues outlined above make plausible the idea that each smart city or group of smart cities should own or work with a research-development-innovation center, in order to achieve improved technological solutions and develop new ones. These solutions should take into account all the parameters mentioned before and the balance concerning the human-system dependability, so that people develop harmoniously and healthily, including the psychological and sociological perspective.

In addition, in the context of regional development, rural areas should by no means be ignored, especially those not under the influence of urban poles and which are somewhat isolated. Rural areas present a number of advantages that are complementary to those in urban areas, providing resources and specific facilities. It is therefore necessary that development and smart specialization to be implemented in these areas, in line with the policies and strategies of the cities nearby, so that to produce synergies to enhance their attractiveness for investors and for those who wish to live and work in these areas. Smart development can be done on several levels, one of the essential investment parameters being the added value per area. Thus, intelligent systems can be introduced for irrigation, river flows control, transportation of all kinds, telecommunications, education (ex. digital), medicine (e.g. telemedicine) and so on. The connection between urban and rural

areas is necessary to be produced both physically and virtually.

Creating cities associations, with legal personality or not, which have the vision of transforming into smart cities is desirable. The motivation is simple, proven throughout history that human evolution was always realized by using synergies and based on the ability and the will to learn and progress. These associations could cause more harmonious development, through a synchronous policy of smart specialization, by also assisting the development of rural areas on the connecting routes and thus increasing the performance of the entire region to which they belong.

III. CONCLUSIONS

This work can be considered a preliminary contribution to the development of future research in order to obtain a better understanding of the current phenomena of smart cities. Summarizing, a smart city is made by land, citizens, technology and governance; it could have larger or broader boundaries, from the local urban dimension of a single city, to a region, a network of city, towards the national and global dimension; it should have well defined and measurable goals, regarding these aspects: the environmental sustainability, the creation of smart intellectual capital, the citizens participation and the wellbeing; it is smart because it is intelligent, digital, wired, sustainable, inclusive, democratic etc. (extended from [5, 24]).

The urban systems to be deployed in the smart cities of 21st century are very complex and have to be driven and managed by solid development visions, strategies and competencies. Many aspects have to be considered: technical, economic, social, territorial, environmental, juridical, with respect to efficiency, security, adaptability, sustainability etc. The collaboration with research and development centers is a necessity, as the solutions are ever changing and have to be identified, designed, implemented, adapted and improved.

There are no miraculous fixed solutions for the cities, each one has to take into account the local multivalent specificities and, moreover, they have to adapt themselves over time to the changes of reality. Collaboration platforms and smart specialization among the cities in a region are prerequisites for these cities to survive and prosper in the global and competitive world.

Alike the standalone solutions, synergies among the collaborating cities have to be designed specifically for that area, by covering also the rural spaces in between. Smart cities connection is not in deep study, so there is a lack of knowledge in the field. The solutions for creating smart cities and smart city connections have to be carefully conceived and implemented, adapted to the local and contextual realities and improved over time, by human or automatic interventions.

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Students' entrepreneurial potential and the role of entrepreneurial education - A Comparative study between Romania and Greece

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Abstract – The purpose of this paper is twofold. On the one hand, the paper draws a comparison between the national entrepreneurial potential and characteristics in Romania and Greece, using the Global Entrepreneurship Monitor (GEM) statistics. On the other hand, the paper aims to investigate the students' entrepreneurial potential and the role of education, considering the case of two technical universities, one from Greece and one from Romania. While at national level the latest GEM data indicates a higher entrepreneurial potential for Romania, the institutional comparison made, and the statistical data processing, underline the gap of entrepreneurial education in both universities. More precisely, using the questionnaire approach, we show that students hardly perceive the role of courses related to entrepreneurship. Thus, the courses taught at the analyzed universities fail in highlighting and developing entrepreneurial skills, although their structure and topics are related to entrepreneurship. These results have practical implications and they serve to find solutions for improving the entrepreneurial education in both institutions.

Keywords: entrepreneurial potential, entrepreneurship education, survey, Greece, Romania.

I. INTRODUCTION

Entrepreneurship is considered one of the most powerful economic forces known to humankind [7], which enhances productivity, and contributes to the economic development [16]. It supposes the existence and use of creativity and innovation, but also risk taking and passion. Entrepreneurship is perceived as "any attempt at new business or new venture creation, such as self-employment, a new business organization, or the expansion of an existing business, by an individual, a team of individuals, or an established business" [13].

Alongside the impact of exposure to entrepreneurial activities [23], self-efficacy and risk-taking capacity [6], and even gender [8, 10, 21], the role of the entrepreneurial education cannot be neglected [9, 15, 18] in enhancing the intentions to entrepreneurship. While there is a plethora of studies that investigate the role of education in developing the entrepreneurial skill, and favoring entrepreneurial intentions, only few of them focus on the role of higher education [11, 12]. Further, as far as we know, there are no studies that perform a cross-country comparison between two higher education institutions, starting from a comparison between the national entrepreneurial potential ([3] represents an exception).

To fill in this gap, we start our analysis from an ample comparison between two countries with a different historical economic background, namely Greece and Romania. While Greece benefited from a market economy system, where the initiative to start and develop new ventures was encouraged, Romania is a former communist country, where the entrepreneurial attitude was completely discouraged before 1990. We continue this analysis with the assessment of students' entrepreneurial potential and the role of the entrepreneurial education in two technical universities, namely the Alexander Technological Educational Institute of Thessaloniki (from Greece), and the Politehnica University of Timisoara (from Romania). Indeed, [3] a comparison between the entrepreneurial courses in the above-mentioned higher education institutions was done. However, the authors of [3] did not confront their findings with the national entrepreneurship potential, neither did they provide the practical implications of their study.

II. A COMPARISON BETWEEN THE ENTREPRENEURIAL POTENTIAL OF GREECE AND ROMANIA

The Global Entrepreneurship Monitor provides high quality reports about the entrepreneurial activity worldwide. It is well known that the GEM is a trusted

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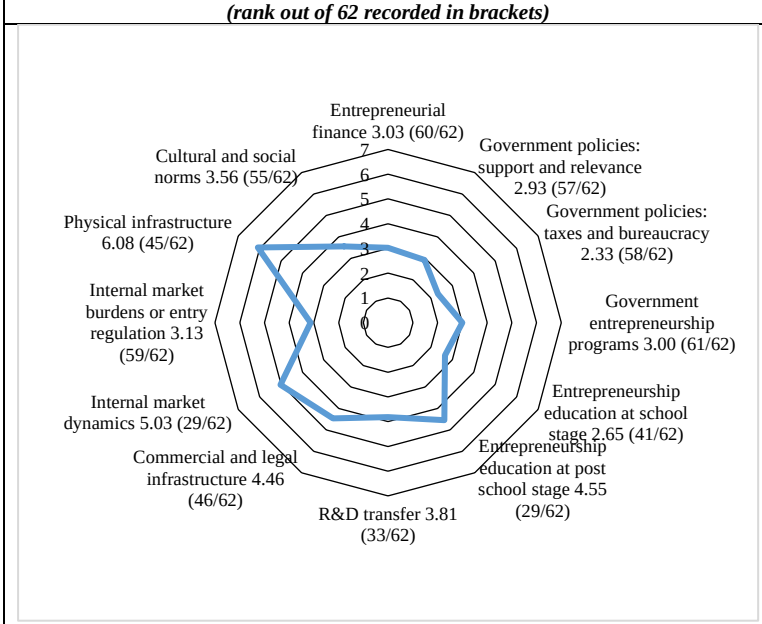
resource on entrepreneurship data for key international organizations like the United Nations, World Economic Forum, World Bank, and the Organization for Economic Co-operation and Development [5]. Noteworthy studies employ the GEM data for their analysis [1], or even make a bibliometric analysis of researches that use these data [16].

Starting from the last 2015/2016 global report [5], figure 1 and 2 present the two countries' entrepreneurial profile, and some information regarding their economic development. According to the GEM report, Greece is an innovation-driven economy, while Romania is an efficiency-driven economy. In Greece (Figure 1), the total early-stage entrepreneurial activity increased over the last year. However, only 60% of the population consider that entrepreneurship is a good career choice. These results might be influenced by the recent debt crisis experienced by Greece.

Greece - Economic indicators

- Population: 11.10 million (2014)
- GDP: $238.0 billion (2014)
- GDP per capita: $21,653 (2014)
- SME contribution to GDP: 75% (2014)
- World Bank Doing Business Rating: 68/100; Rank: 60/189
- World Bank Starting a Business Rating: 91/100; Rank: 54/189
- World Economic Forum Global Competitiveness Rating: 4.0/7; Rank: 81/140
- Economic Development Phase: Innovation-Driven

Expert Ratings of the Entrepreneurial Eco-system (rank out of 62 recorded in brackets)



Entrepreneurship characteristics		
Self-Perceptions About Entrepreneurship	***Value %***	***Rank/60***
Perceived opportunities	14.2	60
Perceived capabilities	46.8	34
+Fear of failure	46.9	55
*Entrepreneurial intentions	8.3	51
Activity	***Value %***	***Rank/60***
Total Early-stage Entrepreneurial Activity		
TEA 2015	6.7	49
TEA 2014	7.9	n/a
TEA 2013	5.5	n/a
Established business ownership rate	13.1	11
Entrepreneurial Employee Activity – EEA	1.0	43T
Motivational Index	***Value %***	***Rank/60***
Improvement-Driven Opportunity/Necessity Motive	1.5	42T
Gender Equity	***Value %***	***Rank/60***
Female/Male TEA Ratio	0.8	13T
Female/Male Opportunity Ratio	0.9	24T
Entrepreneurship Impact	***Value %***	***Rank/60***
Job expectations (6+)	4.3	57
Innovation	1.6	47T
Industry (% in Business Services Sector)	19.4	23
Societal Value %s About Entrepreneurship	***Value %***	***Rank/60***
High status to entrepreneurs 31	67.8	31
Entrepreneurship a good career choice	60.9	29T

Fig. 1. Entrepreneurship country profile for Greece [5]

Romanians have similar perceived capabilities, but the perceived opportunity to start a business is over 33% (Figure 2). However, both countries are placed in the last quartile regarding the way the respondents see the opportunity to start a business. Different from Greece, in Romania the entrepreneurial activity is highly appreciated.

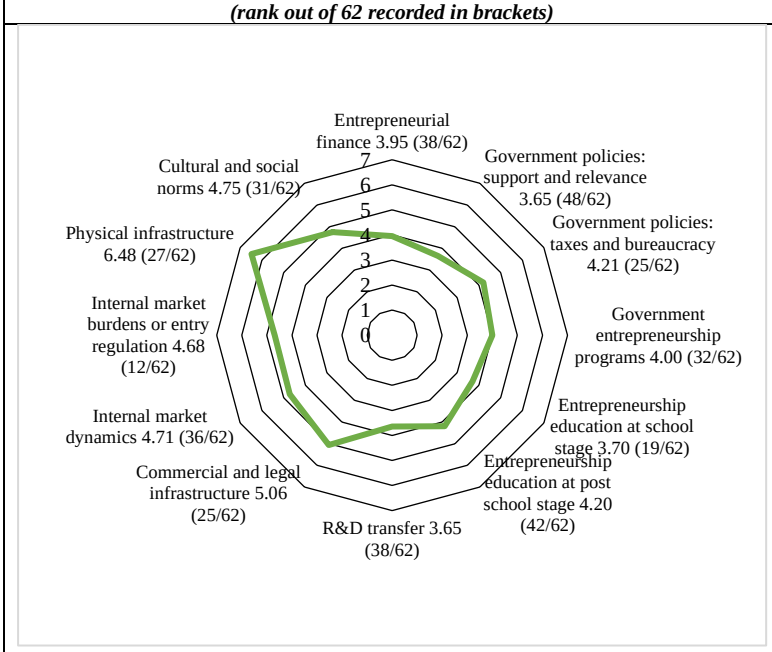
Information on entrepreneurial dynamics for Romania and Greece is presented in Figure 3. The total early-stage entrepreneurial activity rate (percentage of individuals aged 18-64 in an economy who are in the process of starting a business or are already running a new business, not older than 42 months) in Romania is 11.3%, a higher rate than in Greece (7.9%). The established business ownership rate (percentage of individuals aged 18-64 in an economy who own and manage a business older than 42 months) reaches in Greece 12.8%, overpassing that of Romania (7.6%). The discontinuation rate (percentage of individuals aged 18-64 who owned a business but discontinued it for different reasons during the last 12 months) is around 3% in both countries. The results can be

explained by the economic development gap between the two countries. Romanian entrepreneurs are more active in the early stage, and Greeks entrepreneurs are considered to be more mature.

Romania - Economic indicators

- Population: 19.9 million (2014)
- GDP: $200.0 billion (2014)
- GDP per capita: $10,035 (2014)
- SME contribution to GDP: 50% (2014)
- World Bank Doing Business Rating: 74/100; Rank: 37/189
- World Bank Starting a Business Rating: 92/100; Rank: 45/189
- World Economic Forum Global Competitiveness Rating: 4.3/7; Rank: 53/140
- Economic Development Phase: Efficiency-Driven

Expert Ratings of the Entrepreneurial Eco-system (rank out of 62 recorded in brackets)



Entrepreneurship characteristics

Self-Perceptions About Entrepreneurship	***Value %***	***Rank/60***
Perceived opportunities	33.3	45
Perceived capabilities	46.3	35
+Fear of failure	40.5	42
*Entrepreneurial intentions	29.0	16
Activity	***Value %***	***Rank/60***
Total Early-stage Entrepreneurial Activity	10.8	30T
TEA 2015	11.4	n/a
TEA 2014	10.1	n/a
TEA 2013		
Established business ownership rate	7.5	25
Entrepreneurial Employee Activity – EEA	4.6	17
Motivational Index	***Value %***	***Rank/60***
Improvement-Driven Opportunity/Necessity Motive	1.2	49
Gender Equity	***Value %***	***Rank/60***
Female/Male TEA Ratio	0.5	38T
Female/Male Opportunity Ratio	1.1	3T
Entrepreneurship Impact	***Value %***	***Rank/60***
Job expectations (6+)	39.8	4
Innovation	3.2	27T
Industry (% in Business Services Sector)	17.6	29
Societal Value %s About Entrepreneurship	***Value %***	***Rank/60***
High status to entrepreneurs 31	75.1	18
Entrepreneurship a good career choice	72.4	12

Fig. 2. Entrepreneurship country profile for Romania [5]

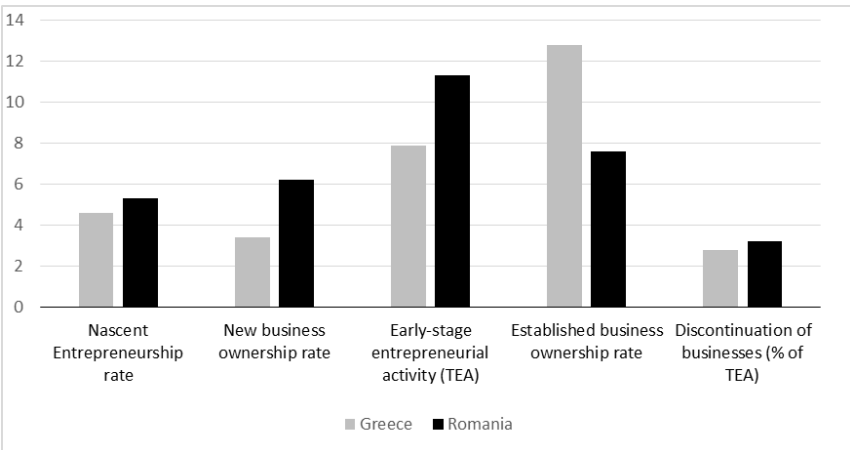


Fig. 3. Phases of entrepreneurial activity in the GEM economies in 2015, by geographic region (% of population aged 18-64) [5]

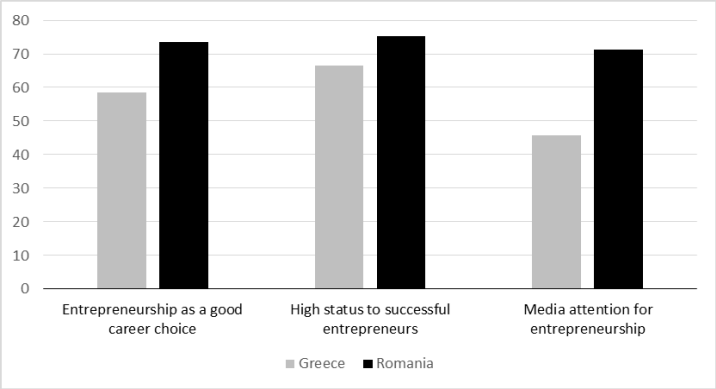


Fig. 4. Phases of entrepreneurial activity in the GEM economies in 2015, by geographic region (% of population aged 18-64) [5]

There is a clear difference between Romania and Greece in terms of social values towards entrepreneurship. Indeed, Romanians have a strong, positive perception related to these features, while this is not the case for the Greeks, especially for the media attention for entrepreneurship (Figure 4).

Figure 5 provides a comparison in terms of individual attributes towards entrepreneurship in the two countries. Perceived capabilities are higher than perceived opportunities in both countries. Similar results are reported by [3], using the GEM statistics for 2013, which shows that there is no significant change recorded in the comparison over the last years.

In this context, the objective of the present paper is to discuss the comparative survey results obtained in two universities (from Romania and Greece) in order to discover gaps of entrepreneurship education in terms of learning outcomes perception. The research aims to investigate students' entrepreneurship potential and the education in the field.

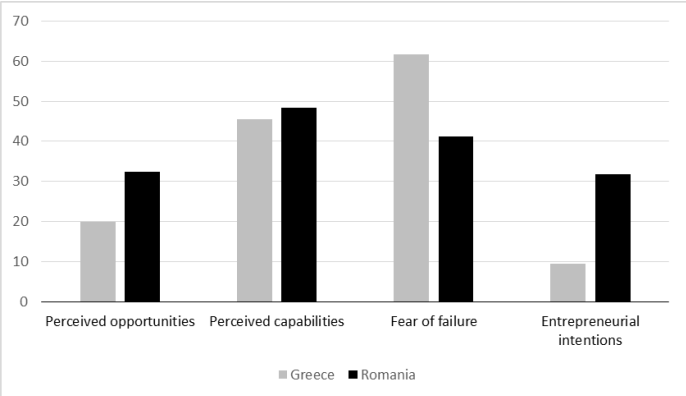


Fig. 5. Individual attributes towards entrepreneurship (% of population aged 18-64) [5]

III. THE ENTREPRENEURSHIP EDUCATION: A CHALLENGE FOR THE EU

The main initiative in the field of entrepreneurship in the European Union (EU) is defined by the 2020 Action Plan[10] which proposes "to bring Europe back to growth and create new jobs, we need more entrepreneurs". According to the proposed strategy and the associated plan, three areas for immediate intervention were identified:

a. "Entrepreneurial education and training to support growth and business creation;
b. Removing existing administrative barriers and supporting entrepreneurs in crucial phases of the business lifecycle;
c. Reigniting the culture of entrepreneurship in Europe and nurturing the new generation of entrepreneurs".

On the other hand, the European Commission reports from 2014 [4] regarding entrepreneurship education highlights the following needs:

- "Introduce entrepreneurship as an explicit curriculum objective for formal and non-formal education at national level, supporting this with implementation guidelines;
- Ensure that curriculum frameworks are flexible enough to enable introduction of more innovative teaching and assessment methods, giving educators and education institutions the flexibility to choose the most appropriate approaches for their teaching;

[10] The Entrepreneurship 2020 Action Plan, https://ec.europa.eu/growth/smes/promoting-entrepreneurship/action-plan_ro

- Encourage interdisciplinary curriculum approaches to support and enhance the introduction of entrepreneurial methodologies at education institution level; make practical entrepreneurial experiences widely available throughout all stages of education and training, with a minimum of one during compulsory education for all learners;
- Make entrepreneurial learning relevant to the real-world through active engagement between education, business and community, particularly in the design and development of practical entrepreneurial experiences;
- Encourage the use of innovative Information and Communication Technologies (ICTs) based learning in entrepreneurship education
- Share good practice and encourage collaboration between formal and non-formal education environments".

Consequently, the challenge is to develop interdisciplinary approaches, making entrepreneurship education accessible to all students specialization curricula, creating teams for the development and exploitation of business ideas, mixing students from economic, business, engineering studies with students from other specializations and with different backgrounds (by interdisciplinary training modules or courses) [14, 20]). Universities have a key role in these developments, through their high quality and effective entrepreneurship programs [2].

In 2015, the European Parliament adopted a resolution on promoting youth entrepreneurship through education and training. In this context, it was recognized that: "*Some Member States have yet to develop a cross-cutting policy or a strategic approach to entrepreneurship education or entrepreneurial curricula and teaching methods; whereas not all teachers and education leaders in Europe are sufficiently trained in entrepreneurship education'; and 'stresses the need for a broad approach to entrepreneurship as a set of transversal key competences for personal and professional purposes*"[11].

Furthermore, the European countries are characterized by high youth unemployment rates, and rapid changes related to the ongoing complex knowledge-based economy and society. In this context, transversal skills such as entrepreneurship are essential not only to shape the mindsets of young people, but also to provide the skills, knowledge and attitudes that are central to developing an entrepreneurial culture.

In this context, defining entrepreneurship education represents a big challenge. Classical business or economic studies are not enough to develop an entrepreneurial culture. It was therefore agreed that existing activities and programs, recognized as education for entrepreneurship, are those that include at least two of the following elements [2, 9, 11, 12]:

a. "Developing those personal attributes and generally applicable (horizontal) skills that form the basis of an entrepreneurial mindset and behavior;
b. Raising students' awareness of self-employment and entrepreneurship as possible career options;
c. Work on practical enterprise projects and activities, for instance students running small companies;
d. Providing specific business skills and knowledge of how to start and successfully run a company".

Some relevant aspects regarding the status and the dynamics of the entrepreneurship education in Europe were presented by [2]. Research shows generally low levels of participation in practical entrepreneurial learning at school and a need to further develop the entrepreneurial skills of young people. According to the special Eurobarometer survey, Entrepreneurship in the EU and beyond, published in 2012, just less than a quarter (23 %) of the EU respondents said they had taken part in a course or activity at school relating to entrepreneurship, defined as turning ideas into action and developing one's own project. Furthermore, younger respondents were twice as likely to have taken part in an entrepreneurship course.

IV. RESEARCH DESIGN AND METHODOLOGY

The comparative study was developed in the Alexander Technological Educational Institute of Thessaloniki (ATEITH), Business Administration and Economics and Informatics Departments (Greece) and the Politehnica University of Timisoara (UPT), Faculty of Management in Production and Transportation (Romania), using a survey approach. The subjects of the investigation are the students from both institutions. Given the structure of the courses, and the availability of students to complete questionnaires, for the ATEITH, the Bachelor students (250 persons) are the main respondents. They are enrolled in three programs in the field of marketing, and they follow classes with the teaching staff of the Business Administration and Economics Department and of the Informatics Department.

In the case of the UPT, the targeted students (239 persons) follow three on-going Master programs: Engineering and Competitive Management, Engineering and Logistic Systems Management and Entrepreneurship and Business Administration. Few respondents from both universities have already completed a Master program and they currently follow another one. For both institutions the survey was conducted for the academic year 2015-2016.

[11] European Parliament resolution of 8 September 2015 on promoting youth entrepreneurship through education and training. (2015/2006 (INI)).

As we have stated, the research objective is to assess the students' entrepreneurship potential and the education in the field, in the case of two higher education institutions. The self-administered questionnaire used in the survey has the following structure. The first section is meant to characterize the sample, analyzing the gender, the age, the completed education level and the attended specialization. The second section contains ten questions related to students' entrepreneurial potential and entrepreneurial education.

The questionnaire was filled in by 193 students (99 students from UPT and 94 from ATEITH), and all the questionnaires were considered valid. The response rate was 41.42% in Romania, while the students' response rate in Greece was 37.60%. Using SPSS, contingency tables were designed to display the multivariante frequency distribution of the variable. The general statistics implies the calculation of the probability (p), the Pearson's chi-squared test $\chi 2$, the Student t – test, the Mann-Whitney U test, the z-score testing, the Odds R(OD) and the Confidence Intervals (CI).

V. SAMPLE CHARACTERIZATION

From the gender point of view, we notice that the two samples are not homogenous ($\chi 2(1)=27.07$, $p<0.001$).

As expected, given the education level of the students included in the survey (Bachelor and Master students), the age distribution shows that Greek participants are significantly younger, as compared to Romanians ($t(191)=2.136$, $p=0.034$, 95% CI =(0.078 – 1.949).

Another expected result shows that Greek students have lower levels of completed education, as compared to Romanian students ($U=3087$, $z=-5.04$, $p<0.001$). However, for the UPT, there is no significant difference between males and females regarding the completed level of education ($p=0.421$). Within the ATEITH respondents, females have a higher level of completed education as compared to males ($U=672.5$, $z=-2.18$, $p=0.029$). Figure 6 shows that the majority of the Greek students have graduated high school level, while a significant proportion of the Romanian students have graduated bachelor or even master education level.

As for the graduated field, we acknowledge a wide diversity of domains. While the large majority have an engineering background (148 students), the rest of the respondents graduated economics (18 students), journalism (9 students), communication and public relations (7 students), public administration (6 students), mathematics-informatics (3 students), architecture (1 student) and dental medicine (1 student).

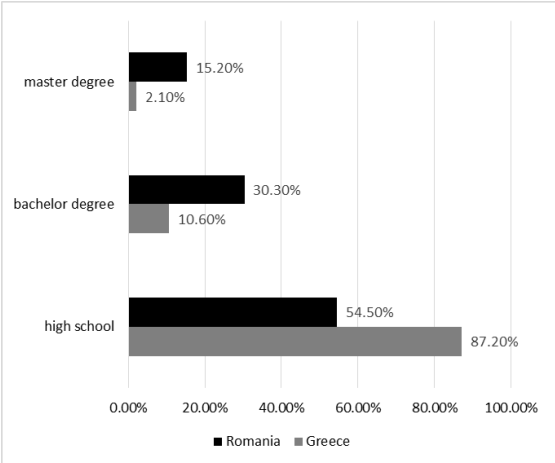


Fig. 6. The sample characteristics

VI. THE ENTREPRENEURIAL POTENTIAL AND EDUCATION

Two directions were followed to assess the entrepreneurial skills development (Figure 7). On the one hand, the entrepreneurial education transmitted through university courses and extracurricular activities was analyzed. On the other hand, the knowledge acquisition for entrepreneurship is assessed based on work experience, previous entrepreneurial experience, and family experience in the entrepreneurial field.

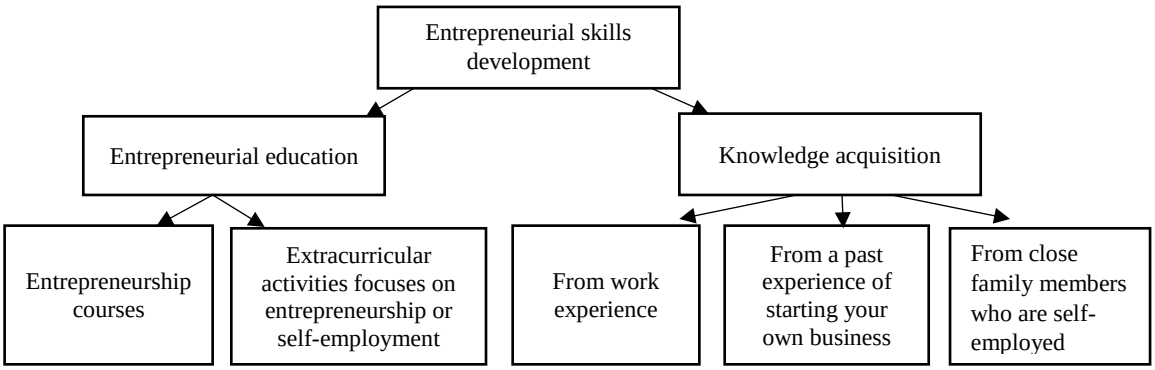


Fig. 7. Students' entrepreneurial skills

The students' enrollment in entrepreneurship courses did not show significant differences between the analyzed institutions ($p=0.378$). Nevertheless, within the UPT sample, males have significantly

attended more frequently entrepreneurship courses, as compared to females ($\chi2(1)=4.20$, $p=0.040$, OR=2.38). This is not the case for the ATEITH respondents, where no significant gender difference is recorded ($p=0.618$).

The results of the questions related to the entrepreneurial education reveal another interesting issue. On the one hand, in the case of complementary entrepreneurship courses, a lack of students' enrollment is seen in both universities. On the other hand, students hardly associated the followed courses (e.g. management general courses, marketing, communication skills are included in most of the specializations curricula at the Bachelor level, in both universities) with the entrepreneurial education. This outcome underlines an inappropriate transmission of entrepreneurial skill to students, in both technical universities. Teachers failed to show how their courses do contribute to the formation of entrepreneurial skills and competences.

The findings also show that the students' entrepreneurial skills were mainly acquired following the involvement in extracurricular activities that focus on entrepreneurship or self-employment. These activities are considered as more interesting and attractive ways for their entrepreneurial education [3]. However, in this case there is also an important discrepancy between the Romanian and the Greek students, explaining thus the different importance paid to entrepreneurship at national level. The UPT students have attended extracurricular activities related to entrepreneurship and self-employment 4.3 times more often in comparison with the ATEITH students ($\chi2(1)=21.33$, $p<0.001$, OR=4.3). This finding can be partially explained by different completed education levels characterizing the two samples. Furthermore, within the Romanian group, the differences between genders are not statistically significant ($p=0.786$). The responses show that 55.3% males and 52.5% females were involved in extracurricular activities in UPT. The Greek students (21.1% males and 21.7% females) are less involved in extracurricular activities dedicated to entrepreneurship or self-employment.

In terms of knowledge acquisition in the entrepreneurship field, the first analyzed item (Figure 7) is the work experience. In this case there is no significant difference related to the average length of the work experience between the respondents of the two institutions ($p=0.340$). Most of the Romanian students have less than one year of work experience (34.2% of the male and 68.9% of the female students). Furthermore, the females had significantly less work experience as compared to males ($U=758.5$, $z=-3.18$, $p=0.001$). While the Greek students have a similar short term work experience (64.9% of them have less than one year of work experience), the gender comparison shows a reversed result. In this case, females have significantly more work experience, in comparison to males ($U=610.5$, $z=-2.13$, $p=0.033$).

A second entrepreneurial knowledge acquisition item that has been analyzed is the past experience as entrepreneur (by analyzing the students' involvement in their own business). The findings of the survey show that 10.1% of the Romanian students have started a business in the past (23.7% males and 1.6% females), and 9.6% of the Greek students (8.5% males and 13% females). As we can notice, there is no significant difference between countries ($p=0.903$). However, while in Romania the male students are the ones who put into practice their entrepreneurial ideas ($p=0.001$ and Fisher's Exact Test), in Greece, the female students are those who present more developed entrepreneurial intentions, even if in this case there is no significant gender difference ($p=0.687$).

The final item analyzed is the contact with family members who are self-employed. According to the obtained results, 52.5% of the Romanian students and 58.5% of the Greek students have recognized that they have close family members who are self-employed. First, there is no difference between countries, related to the frequency of having close family members who are self-employed ($p=0.404$). Second, within the Romanian group of students, males declare having close family members who are self-employed more frequent than females ($\chi2(1)=6.29$, $p=0.012$), a result which sustains the previous findings showing a higher males involvement in entrepreneurial activities. Third, there is no significant gender difference in the case of the Greek group of students ($p=0.095$). All in all, students' hardly associate the contact with a family member who is self-employed as a source of entrepreneurship. The results of the second section of the questionnaires are synthesized in Table 1.

In the second step, we have analyzed students' confidence on their 20 abilities of becoming entrepreneurs (Table 2).

Table 1. Synthesis of the research results on education and knowledge acquisition in the field of entrepreneurship

Data process of YES answers	***Romania***	***Greece***
Entrepreneurship courses	37.4%	43.6%
Extracurricular activities on entrepreneurship or self-employment	53.5%	21.30%
Entrepreneurship education (average score)	*45.45%*	*64.90%*
Entrepreneurship knowledge acquisition from work experience	55.60%	64.90%
Entrepreneurship knowledge acquisition from past experience on starting own business	10.10%	9.60%
Entrepreneurship knowledge acquisition from self-employed family members	52.50%	58.50%
Entrepreneurship knowledge acquisition (average score)	*39.40%*	*22.70%*

Table 2. Students' confidence in their entrepreneurial abilities

How much confidence do you have in your ability to....?	***Average confidence score (1 low …5 highest confidence):***		***Entrepreneurship education subjects***
	Romania	***Greece***	
1. Lead and manage a team	3.71	3.49	Human resource management
2. Identify ways to combine resources in new ways to achieve goals	3.49	3.41	Innovation and creativity
3. Manage time during projects	3.58	3.34	Project management
4. Brainstorming for new ideas discovering	3.64	3.54	Innovation and creativity
5. Put together the right group/team in order to solve a specific problem	3.81	3.36	Human resource management
6. Conduct analysis for a project that aims to solve a problem	3.44	3.33	Business analytics and management
7. Read and interpret financial statements	2.74	2.79	Project management (Accounting and finance)
8. Identify potential sources of resources	3.23	3.05	Business analytics and management
9. Persist in the face of setbacks	3.17	3.04	Risk management
10. Networking capacity and skills	3.71	3.47	Communication
11. Set and achieve project goals	3.80	3.77	Project management
12. Learn from failure	4.21	4.05	Risk management
13. Get others to identify with and believe in my visions and plans	3.62	3.50	Human resource management
14. Clearly and concisely explain verbally/in writing my ideas in everyday terms	3.46	3.17	Communication
15. Manage uncertainty in projects and processes	3.21	3.23	Risk management
16. Work productively under continuous stress, pressure and conflict	3.28	3.21	Human resource management
17. Think outside the box	3.78	3.72	Innovation and creativity
18. Estimate a budget for a new project	3.19	3.72	Project management (Accounting and finance)
19. Easy find a solution for each problem	3.69	3.54	Innovation and creativity
20. Start his/her own business	3.88	3.64	Business analytics and management

These abilities are afterwards confronted with related education subjects that are usually included in entrepreneurship training programs, in order to identify students' entrepreneurial education needs (Table 3). This analysis does not intend to underline gender discrepancies.

As revealed by the set of 20 questions (Table 2), both Greek and Romanian students prove a high confidence related to their entrepreneurial abilities (3.41 and 3.54 respectively). Which are, however, the university courses that contribute to this high confidence? For the Romanian respondents (Table 3), we see that a small confidence and less skills are provided by the project management (including accounting and finance), and a big confidence and good skills are related to innovation and creativity, human resource management and communication.

This result might have two explanations.

- On the one hand, the project management and financial courses may seem as too technique and may fail in transmitting entrepreneurial abilities.
- On the other hand, a good understanding of all elements implied by business development, including planning and financing, may determine students to become less confident in their ideas, given the complexity of tasks involved by business development.

Greek students have small confidence and skills in communication, but big confidence and good skills in innovation and creativity, risk management and project management (Figure 8).

Table 3. Students' confidence on their abilities related to education subjects in the field of entrepreneurship

Entrepreneurship education subjects:	***Average confidence score***	
	Romania	***Greece***
Business analytics and management	3.52	3.34
Human resource management	3.61	3.39
Project management (including accounting and finance)	3.33	3.41
Innovation and creativity	3.65	3.55
Risk management	3.53	3.44
Communication	3.59	3.32

Total average score	***3.54***	***3.41***

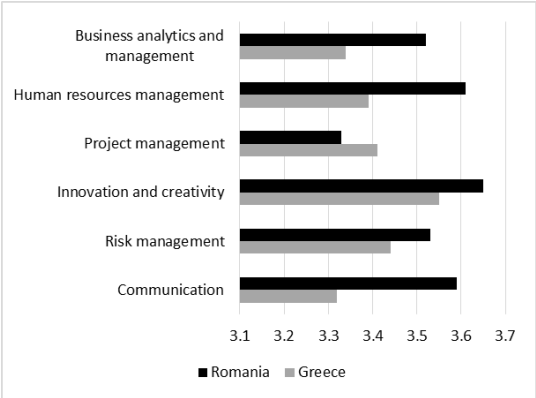


Fig. 8. Graphical representation of students' confidence

VII. CONCLUSIONS

The purpose of the present study was to provide an answer to the following question: How should the entrepreneurship education in technical universities (particular in the case of UPT and ATEITH) be reconsidered to create effectiveness and satisfaction for their students? In order to find an answer to this question, we have made an institutional comparison, starting from the assessment of the entrepreneurial potential of Romania and Greece, using the GEM statistics.

At national level, it seems that Romania has a greater entrepreneurial potential than Greece, although it is considered an efficiency and not an innovation-driven economy. These results are correlated with the institutional-level findings.

For assessing the impact of entrepreneurial education and entrepreneurial knowledge acquisition in the two technical universities, 193 questionnaires were collected. In general, the recognition of the entrepreneurial education is higher in Greece (64.90% of Greek students have respond with "yes") than in Romania (45.45%). However, acquiring entrepreneurial skills from alternative sources (work experience, self-employment) is not seen as the best practice by students from both countries (only 39.40% of Romanian students and 22.70% of Greek students have respond with "yes").

The synthesis and conclusions of the research results related to students' confidence on their 20 abilities related to entrepreneurial skills, and their connection with the education in the field have been analyzed and debated by teachers and trainers from both universities, in order to re-design the university curricula. While in Greece there is a strong need for communication and business analytics and management skills development, in Romania the strong need is for project management skills and financial skills development.

These results have practical implications for universities' managers who shall enhance the entrepreneurship curricula followed by students of all specializations. This curricula should be interdisciplinary and different faculties and departments from both institutions should be involved.

Our findings have also practical implications for researchers acting in the entrepreneurial education field in both institution, who must cooperate in order to develop good practices and to help designing adequate programs for entrepreneurship.

Several limitations characterize our research. First, the small sample size can bias the results. Second, there is a high diversity of respondents regarding their undergraduate studies. Third and most important, the comparison is made considering in particular students from Bachelor level in Greece, and students from Master level in Romania. The entrepreneurial perception evolves and the entrepreneurial skills are progressively acquired. Therefore, a better perception of Romanian students about their knowledge acquisition in the field, as compared to the Greeks, is quite normal.

Finally, our research has an interesting outcome. We notice that in Greece, which according to Hofstede [24] is a masculine country (MAS 57) compared to Romania (MAS 42), female students are more entrepreneurship oriented, while in Romania the male students are more confident in their entrepreneurial skills and they are those who usually start a business.

VII. ACKNOWLEDGEMENTS

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State of the Art on Relevant Research Areas Connected to Complexity Management

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Abstract – The article is focus on describing the connected or associated concepts and disciplines for managing complexity. The approach will follow: (1) the holistic perspective; (2) the specific approach of complexity management (service-related); (3) the special (nonservice-oriented) research areas of complexity management; (4) characteristics of complexity in outsourcing projects. In the final chapter, relevant conclusions related to the state of the art will be made. The aim of the article is to emphasize the necessity of viewing complexity management as a new organizational challenge and initiatives. The main finding of the research consists of the identification of different knowledge sources related to complexity management connected disciplines that have to be considered by managers in order to define successful strategy, methodologies and processes.

Keywords: complexity, management, outsourcing, project management, Industry 4.0

I. INTRODUCTION - THE COMPLEXITY ROLE IN PROJECTS RELATED TO INDUSTRY 4.0

In the last years, companies are currently facing the challenges of increasing products and services customization, increasing resource efficiency and shortening the time-to-market. These challenges need an IT diffusion to all company functions and areas, to support networking develop products, manufacturing resources and processes. These concepts are often grouped under the Industry 4.0 strategy [32]. In 2015, a study with 56 experts from industry has recognized the key success factors that are innovation, flexibility and complexity management, and data security [58].

Fraunhofer Institute, with various universities and industrial companies, develops Industry 4.0 initiative, strategy. In 2013, the Institute published a study done with 661 manufacturing companies, supplemented by 21 renowned experts in the industry, leading scientists and association and trade union representatives. Because of the survey, three future-relevant topics were identified as particularly important and urgent: dealing with complexity, innovation capacity and flexibility [52].

In the same context, Bauernhansl sustained that the assessment of the Industry 4.0 potentials in large company can be done via so-called “use cases”. He considered these as application scenarios that use Industry 4.0 technologies. He suggested that preliminary, there have to be analyzed the internal environment of the large company in order to identify which use cases are useful for the application and for which the Industry 4.0 technologies are possible to be used. A graphic detail in Figure 1 illustrates these relationships [3].

Industry 4.0 strategy wants to bring the German industry to be ready for the future challenges. Industrial production has to be able to deliver strong customization products under the conditions of high flexible large-scale production, high degree of customers and business partners’ integration in business and value-added processes and the coupling of production and quality services. New business models and significant potentials for optimization in the context of the production and logistics have to be developed. This adds new services to important areas of application, such as mobility, health, climate and energy [5].

The organization process levels are consistently linked to each other and can be tuned with one another repeatedly based on the most recent process data. Horizontal integration is the starting point of the flexible design of joint value creation processes. Many companies are increasingly confronted with a complex value chain, the steps of which can no longer be described as a chain, but form a web of relationships in which individual companies focus on specific skills. Market volatility continues to grow while the development predictability is declining [6].

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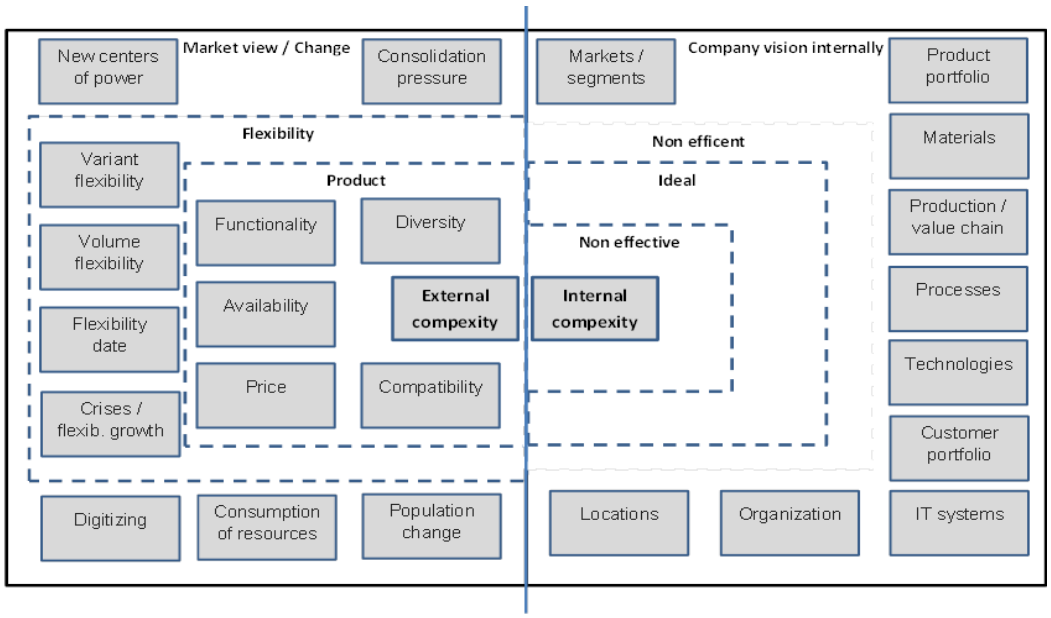

Fig. 1. The complexity explosion [3]

Some institutions and companies currently concretize the development of the value chain in order to control the growing instability. The Deutsche Ingenieure e.V. association published a status report in April 2014 and there have been recognized that product life cycle is increasingly oriented towards individual customer requirements. The life cycle starts with the product idea to order processing and ends with the completion of the order. Through the combination of people, objects and systems dynamic, real-time optimized and self-organizing, enterprise-wide value networks arise in order to support a specific product life cycle [56].

More recent, for the implementation of the Industrial 4.0 Vision there has been recommend to develop an Industry 4.0 roadmap. The following dimensions should be considered [16]: (1) market perspective: customer segments and the structure of the customer needs; (2) product perspective: benefits and added value for the customer; (3) process perspective: resources and technology; (4) network perspective: partners to fulfil customer benefits.

After this brief introduction to the research context defined by the Industry 4.0 strategy, the article will be focus on describing the connected or associated concepts and disciplines for managing complexity. The approach will follow: (1) the holistic perspective; (2) the specific approach of complexity management (service-related); (3) the special (nonservice-oriented) research areas of complexity management; (4) characteristics of complexity in outsourcing projects. In the final chapter, relevant conclusions of the actual references research will be made. The aim of the article is to emphasize the necessity of viewing complexity management as a new organizational challenge and initiatives. Presented researches suggests different knowledge sources related to complexity management (inter-)connected disciplines that have to be considered by managers in order to define successful strategy, methodologies and processes.

II. CONCEPTS FOR MANAGING COMPLEXITY IN BUSINESS SITUATIONS

1. Holistic complexity management

In the following section, scientific concepts will be analyzed and presented, focused on the holistic approach of complexity in business situations.

Gerberich research (cited by [36]) shows that the principal aim in complexity management is creating a balance between internal and external complexity. Gerberich emphasized that not only the reduction should be in the foreground; otherwise, there is a risk that the company is concentrated on its core competencies. In addition, he mentions the following recommendations for action [36]:

- Complexity management is a critical success factor. Not the minimum is desirable, but the optimum;
- The complexity causes have to be recognized. These are often in management, product, organization, and value chains;
- Product and process structuring is the central element of complexity management;
- Complexity management requires real commitment by management;
- Complexity management is an ongoing task and has to be performed from both an inwardly and an outwardly perspective.

The industrial ecology is still a young research filed of interest, with an emphasis on science, engineering and planning sciences. It searches for viable solutions to manage business processes in ecosystems and deal overall, with the increasing complexity and uncertainty. A guiding principle of this research discipline is that there are no laws of nature dealing with complexity. The human mind is led by motives, which has a significant influence on the

approach in dealing with complexity in the planning, information gathering and derived actions.

In order to cope with problems in a complex environment, the five processes presented in Figure 2 are recommended; they should always be performed sequentially [14]. The phase *Objectives Labora Transportation* includes the formulation of upper and lower targets, but also the conducting of a situation analysis. In the phase *Information gathering, model creation* a surroundings analysis (technological, legal, economic, social and environmental dimensions) needs to be performed. In the *formation of the model*, the expected effects of the environment must be considered and defined. The analyst must be aware that the results are dominated by a limited perception and rationality (*prognosis* should be developed).

In the next phase, *Planning and decision-making*, the future steps have to be planned. A de-conditionality is to be performed which is an appropriate method in this step. Specifically, this does not mean to carry out detailed planning to reach the overall target, but rather systematically, to proceed in the direction of the target. In the last phase *Controlled action and self-criticism*, the previous steps must be reflected; results should be discussed in a group. At the end, a decision for the next steps must be taken. If a correction of partial results is required, the steps listed shall be repeated. In summary, the following recommendations are given [14]:

- Most of the events are not only dependent on one factor;
- The conditions are changing. The conditions are constantly changing; this must always be considered in carrying out the tasks;
- General rules should be distrusted;
- Detailed planning is not always useful if the complexity of factors can affect the project;
- When carrying out any measure, the actions should be followed by the question: "*Why do you do that?"*

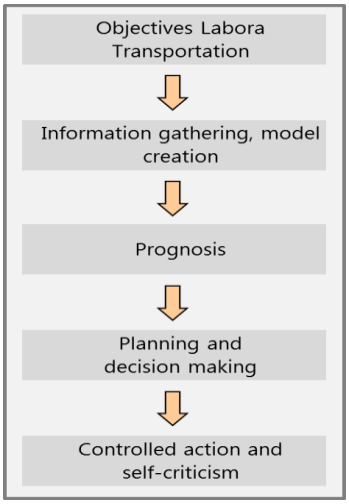

Fig. 2. Process Map Stations of action [14]

According to [15], there is recommend a four-column procedure model for dealing with complexity, which are:

- *Strategy Anchoring*: Anchoring of complexity management in the company's strategy and culture;
- *Transparency*: Complexity transparency costs on product and customer level;
- *Value chain*: Targeted regulation of complexity along the entire value chain;
- *Sustainability*: Tools and systems to ensure continuous monitoring and control.

In the article [37] there is recommended a holistic enterprise wide approach to the complexity of management. It described "*three guiding principles*" for implementation [37]: (1) Comprehensive analysis of the initial situation; (2) Holistic demonstration of various interactions; (3) Constructive management of complexity. The aim is that various influencing factors are taken into account when making decisions; holistic decisions are made by considering interactions, as well as successfully align the company to the complexity of the environment [37].

In addition, [54] have developed a *logic to measure complexity* based on analyzing the different relationships between system's elements. At first, it is differentiated between the node (feature) and second, between the following relationships: mandatory feature relationship (and-relationship), optional feature relationship, alternative feature relationship (case-relationship), groupings of relationships (cardinality) and relationships among nodes and constraint relationships.

More recent in [7], researchers recommend the following eight strategies for mastering complexity:

1. Make complexity transparent:

Analyze and expose areas where complexity arises in an organization and what the related costs and benefits are. Companies can implement this simple system for measuring the degree of complexity in order to streamline the complexity and minimize costs within the organization. This may be realized through a company-wide *complexity index*. For this example, the respective departments, number of portfolio products, brands, legal entities, manufacturing plants and suppliers must be taken into consideration as complexity factors. The company is then able to improve this *basic complexity index* by concrete and targeted measures and thereby control the complexity existing in the company.

2. Apply the 80/20 rule:

In many companies, the 80/20 rule is established and it means that 20% of customers or products account for 80% of sales. This rule can also be applied to the complexity. In the second step, the same calculation for the remaining 20% of revenue shall be carried out. The aim is to identify the customers and products, where a mismatch to the generated turnover exists in order to initiate targeted improvement measures.

3. Optimize the whole, not separate silos:

Silo mentality hinders all efforts to reduce operational complexity systematically. Without a cross-functional, end-to-end view of the entire enterprise, decision-makers tend to concentrate on their

own functions or departments. The silo thinking is a source of process complexity. In order to optimize processes and minimize costs, companies should analyze all critical, cross-functional processes, as well as those that serve internal purposes only. Measuring factors such as time, cost, error, volume and the number of people and points of contact should be considered. This analysis includes the identification of costs and potential costs in processes, systematically.

4. Segregate complexity into separate systems:

Due to the separation of complex products and processes, it is possible for the company to realize the company's standard processes efficiently and in a cost-optimized manner. For example, if a complex product must be built according to customer requirements, it is possible to separate this line of products and the production processes from each other. A part of the production process is made by mass production; other sub-processes, such as finishing work and customization are produced individually.

5. Bundling features together to "standardize" complexity:

By bundling groups of arbitrary functions in standard packages, industrial companies are able to produce standard elements efficiently while providing added value for customers individualized.

6. Defining plant and asset roles:

To minimize the complexity of the production and to achieve more output from the production, network characteristics with the needs of specific products and customers shall be classified. Products with similar characteristics are to be consolidated to achieve greater cost savings, flexibility and efficiency. In the next step, the classification of the preparation of the product lines must be performed in two categories:

- High-volume elements - These requirements are classified into as *high-volume production* with a limited number of products with only a few changes.
- Multi product or flexible assets - For a broader portfolio of small series products or products with volatile or unpredictable demand, production facilities are involved with quick-change ways of reaching versatility and flexibility.

By defining specific asset roll-like *high-volume asset* or *low-volume assets* and creating strict guidelines for the allocation of products to assets, the company has the possibility to reduce the costs per unit.

7. Identifying organizational blockages—and delayer:

Complex organizational structures include layers and interfaces, which have no clear responsibility. There is a risk that difficult decision and obscure responsibility takes place leading to 'orphan' costs and complexities. This complexity, often outside the company, extends to joint ventures, investments, suppliers, subcontractors and other partners. This increases the number of people in the business processes. A high number of interfaces can paralyze the organization in practice in their actions. Moreover, the addressing of organizational complexity management requires a large-screen view. Networks must be analyzed, information flows between organizational silos and blockages have to be identified and relevant processes with no clear owner shall be subjected to a particular observation. The dependencies between functions and interfaces are often not visible and important elements can fall through the cracks. Therefore, it is important to clarify responsibilities, especially for tasks and processes in the organizational units.

8. Challenging assumptions and model new scenarios:

The impact on the cost of complexity is rarely clearly identifiable. By modelling different optimization scenarios, a company can strategically gauge where relevant improvement can be achieved. Often, the findings are not unique. A modelling of the impact of various scenarios for reducing the complexity can show how capacity utilization for the overall performance of the organization behaves [7].

An important achievement for the complexity approach is described in [1], which developed a recommendation methodology called *Seven Steps in the intuitive handling of complexity*. In step 1, *Get the situation*, the core of the problem is described and graphically represented. Step 2 involves the *Intuitive by characterizing the problem into archetypes*. This is an analytical method of psychology to analyze the structure of the collective unconscious. In systems theory, the structure of behavior patterns is described. Step 3 involves the use of archetypes, step 4 *formulating the problem as a dilemma cloud*, as well as the formation of hypotheses, which are then discussed afterwards. Step 5 *questions the hypotheses* put forward. Step 6 is the so-called *Intuition Check* with different approaches, such as encapsulation and thematic vagrancy. Step 7 is the *examination of the methodological approach* of step one to six and a fresh start, if required, to assess the complex situation [1].

In the same context, [13] presented a list of various natural phenomena, which pass over a system behavior of a complex state in a chaotic state. As an example, there have been used a sand pile, where an additional grain of sand is sufficient for an avalanche. This sensitive dependence of a system behavior, for example, of the initial and conditions is referred to as "*deterministic chaos*". The word "*chaos*" is derived from the Greek language and includes several aspects: complete irregularity, incalculability, unpredictability of the system and the instability of the system state. Deterministic systems are unstable and easily interruptible: Minute alterations lead to large changes in the results. In addition, [13] imposes the following reasons for the steady growth of complexity:

- The functions of systems are constantly being improved;
- Systems are differentiated and flexible so that they can better correspond to a more differentiated reality;
- Systems can be expanded with more and more features to appeal to a wider range of customers;

- Various systems are inter-twined with each other to provide the overall benefit of a combined system.

In [13] there are recommended (like in previous cite researchers, too) capturing complexities through networks and making them tangible. The networks have two types of components: (1) *Node*: these are the place where the connections are linked with each other; (2) *Edge*: these are the connections between the nodes themselves and edges can possess certain properties.

In [23] there are described the main components of complexity management as follow:

- "The system is a collection of many interacting objects or agents;
- This objects behavior is influenced by storage or feedback loops;
- The objects can adapt their strategies according to their tale;
- The system behavior is usually open;
- The system is to be kept functional;
- The system displays emergent phenomena that are generally unpredictable, and can take extreme forms;
- The emergent phenomena typically occur in the absence of any kind of "*invisible hand*" or "*central management*";
- The system displays a complicated mix of ordered and disordered system behavior".

Furthermore, [27] recommends a five-point programme to control complexity by taking into account the following organizational issues: 1) Product; 2) Process; 3) Production; 4) Innovation; 5) Personnel.

In [22] there is described a generic and holistic complexity model (*Complexity: Toward an empirical measure)* by defining the *Generalized Complexity Index* (GCI), with three dimensions: *Multiplicity*, *Diversity* and *Interconnectedness*. The base of the complexity evaluation model was originally the product management; however, it can also be applied in a generic context, such as organizational review. For each of the dimensions, a mathematical formula was defined as described in the following [22]:

$$Multiplicity = \#\ of\ variants = V; \quad (1)$$

$$Diversity = 1 - (unique\ elements/total\ elements) = 1 - U/T; \quad (2)$$

$$Interconnectedness = connections/max\ connections = A / M. \quad (3)$$

This approach suffer from of the lack of uncertainties consideration and because of it is most suitable to product management.

In 2013, there have been developed a model to analyze and present complexity in a graphical way, called "*The House of project complexity*". The core of the model are the following two dimensions: (1) institutional features and (2) technical features. [33], presented in Figure 3.

More recent in [53] there have been presented a model dealing with complexities focus on the researches and modelling is the "*definiteness degree of information"*. Starting point is the idea that business decisions are nowadays usually meet in an environment that is characterized by indirect effects, relationship networks and delays. Nevertheless, the identification and mapping system contexts in decision-making is often limited as cause-effect relationships and generally leads to erroneous handling of complex systems because the actual networking processes of system elements are ignored. The long-time sufficient uncross linked approach reaches its limits at a time of highly complex systems and networks with their respective structures and processes.

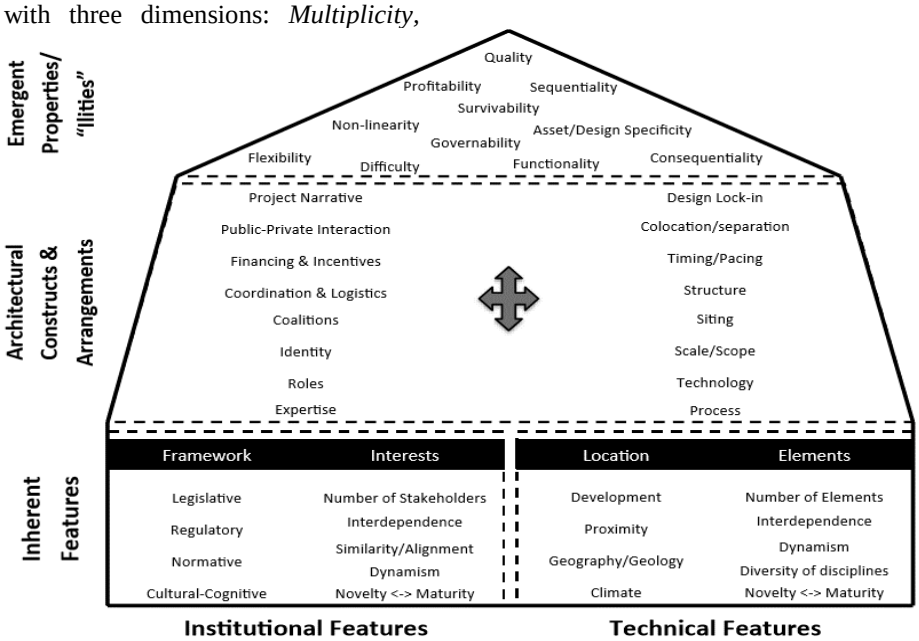

Fig. 3. The full house of Project complexity [33]

The decisive factors in the detection of a complex system are the level of aggregation; the selection of the essential elements of the system and identification of characteristic relationships between the system elements. Therefore, not only the collection of *quantitative information* but also, *qualitative information* is necessary to evaluate the system performance adequately.

The decision problems are characterized by the importance, complexity and the structured nature of the problem, the duration of action and the reversibility problem solving as well as the degree of uncertainty of environmental factors and the dynamics of the environment. The decision field of the decision-maker comprises selectable alternatives or strategies in a given time that state the business environment and the consequences of each alternative course of action in a given state.

Many of the planning and decision-making situations are performed in an environment in which the objectives, constraints and consequences of possible actions are not known in detail. In these cases, the planning and decision-making processes underlying information are imperfect. For the classification of imperfect information, used information can be distinguished by their definiteness as follows: security grade of determination, insecurity and un-sharpness.

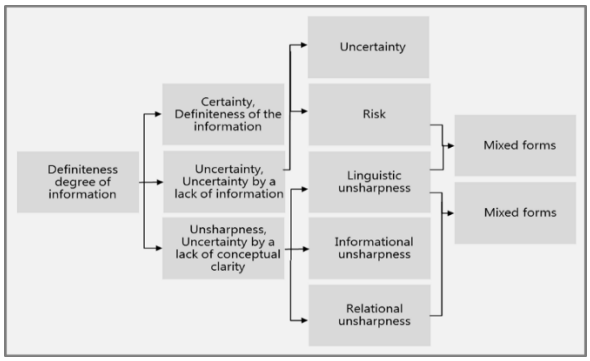

Fig. 4. Certainty degree of information [53]

Strategies	Design	Time effect in ...
Reduce complexity	Reduce the existing complexity	Today
Manage complexity	Efficient handling of unavoidable complexity	Tomorrow
Avoid complexity	Preventing the development of new complexity	Future

Fig. 5. A universal complexity management [60]

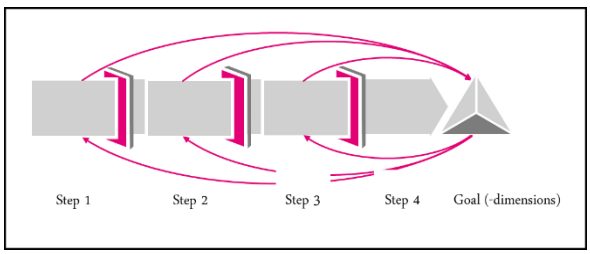

Fig. 6. Transitions Management (derived from [25])

Three types of un-sharpness can be distinguished (see Figure 4) [53]:

- *Linguistic impreciseness*: These are substantive indefiniteness of words and sentences of the human language;
- *Informational un-sharpness*: This type of un-sharpness results from the difficulty to compress a large amount of information about a clear overall judgment. Although they are precisely defined terms, however, a large number of properties is necessary in addition to this comprehensive description;
- *Relational un-sharpness*: This type of un-sharpness includes statements that the mutual dependencies of the included objects do not have dichotomous character. This means that the relationships between the objects are not sharp, by way of example statements like: "A" is greater than "B".

In 2013, [60] has presented 23 functional modules that are considered relevant for complexity management in a company. These are specified in more detail in Figure 5, with respect to a service company and will be used in the present research, too. The complexity drivers in the business environment are manifold; these can be classified into a narrow sense (*detailed view*) and a broader sense (*holistic view*). Based on the detailed view, [60] has also developed three relevant basic strategies:

- *Avoiding complexity* - Through preventive measure the generation of complexity itself is to be avoided. Examples are modularization and standardization of products, organizational structures and processes. A complexity avoidance may not be very pronounced to permanently survive in the market;
- *Mastering complexity* - The aim of this strategy is to handle unavoidable complexities. Caused by external system requirements, internal complexity applies it to dominate as efficiently as possible. The control can for example be done by organizational conditions, flexible interface designs or flexible and scalable IT systems;
- *Reducing complexity* - A reduction can be done through targeted measures in an existing system, for example by reducing the variety of products or the diversity of the system elements and their connections or processes" (prese4nted in [42] based on the research results in [47] and [60])

In 2014, [25] shows how to manage complexity with a systemic focus on a process model in transition management. The transition management focuses on changing the system and is geared towards sustainable development (Figure 6) [25].

In [38] researchers explained that situations in management are often unclear objectives that can be ambiguous, diverse and contradictory. The ideal of the perfect control is an illusion. This ambiguity, lack of

transparency and inconsistency is the justification for the necessity of the role of the manager in the company [38].

The research presented in [47] recommends practical possible tools and methods of managing complexity. Holistic and interdisciplinary approaches are in the foreground. In addition, [47] characterized the complexity drivers using internal and external perspectives, related cluster issues and specific criteria (Table 1).

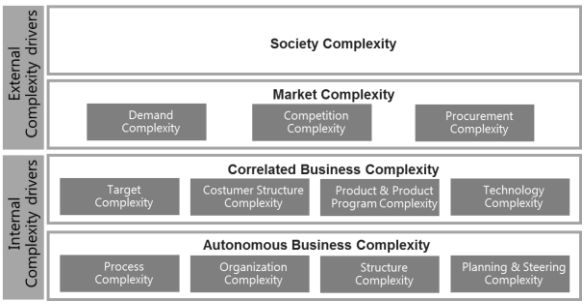

Fig. 7. Complexity drivers [47]

Table 1. Complexity drivers [47]

Complexity drivers		
View	***Cluster***	***Criteria***
External complexity drivers	Society complexity	– changing values; – environmental awareness; – economic and environmental factors; – political framework;
	Demand complexity	– diversity of customer requirements; – individuality of the demand; – market dynamics; – global requirements;
	Competition complexity	– number of strength of competitors; – changing markets; – competitive dynamics; – globalization;
	Procurement complexity	– number of suppliers; – procurement strategy and concept; – fluctuations in demand; – uncertainty of the delivery or quality;
Internal complexity drivers	Target complexity	– number of tracked targets in parallel – dynamics of the target adjustment – maturity of goal achievement
	Costumer structure complexity	– number of customers and customer groups – heterogeneity of customers and customer groups – level of participation
	Product and product program complexity	– structure of products – product and version number – dynamics of the product changes
	Technology complexity	– technological change – availability (innovative) technologies – technology lifecycle
	Process complexity	– number of interfaces and design – degree of crosslinking of the processes – degree of standardization
	Organization complexity	– number of hierarchy levels – degree of centralization – number of organizational units
	Structure complexity	– number of distribution levels – number of stock, staff, equipment, ... – communication systems – vertical integration
	Planning and steering complexity	– communication systems – frequency and level of detail of the management and control area

In [57] is presented an analysis based on past research objects, and on the following six main strategies:

- High sensitivity: pay attention to weak signals, establish a broad radar, high attention and mindfulness;
- Interpretation of information, think and play through possible consequences, create and study the connections, promote variety of thought (simulation);
- Management is a permanent process of progressing and the road map is drawn just during the walking;
- Flexibility, perspectives change, think in the view of the involved parties and contacts;
- High responsiveness by high problem solution ability and increased inside complexity (resources, potentials and options);

- Higher security to be able to master uncertainties better (stability and mistake tolerance).

In [57] is proposed a method, originally based on the VUCA (Volatility – Uncertainty – Complexity – Ambiguity) concept, which was developed in 1995 in the military field and which has been developed further. The core of the strategy is thinking in options and chances. The management observes emphatically the development of the defined scope (e.g. in projects), preparation is made for pre well-thought-out options in parallel, around then at the right moment, possible measures will be initiated to perceive an expected chance.

In [39] is introduced a special concept: "*Komplexithoden"* (in German) that link complexity and method words. According to this approach, for coping with complexity, numerous concrete tools are recommended:

- Methods for performance;
- Methods for agility related to dissolution of workplace, agile project work and the sense making.
- Methods for learning related to the informal structure work, communities of interests/practice and cultural observation.

Within these basic adjustments, concrete proposals for methods were developed [39]. Due to the limited extent in this research, only three methods for each strategy category are listed and analyzed.

In [59] research is presented a package of complexity management methods with focus on *supply chain management*. After an extensive analysis of the external and internal complexity drivers, a method for visualization is presented. On this base, some methods for *change and/or reduce complexity* are discussed in detail. These methods are designed for the strategy "*Complexity design*" [59]. According to the same reference, the following methods were created for the strategy of c*omplexity control*: project planning; changing demand; IT as an enabler and logic of communication.

A holistic and relevant approach for the present by [24]. The focus of their research was the complexity caused by the environment and the development of a concept of utilizing the illustrative capacity of modelling, in order to understand processes and decision-supporting scenarios. Here small and large-scale situations are considered. In large scale, focusing on the processes within a system and existing trends are explained. In small case systems, the focus is directed to the characterization and the importance of the parameters that describe a system itself. The systems' environment is characterized by the following criteria [24]: large-scale and long-term; multicomponent; real world conditions; multiscale and multidisciplinary; multivariate and nonlinear. The structure of a complex system can be modelled in a sequential procedure as suggested in the following [24]:

1. "Describing the relevant system;
2. Identifying actual variables;
3. Checking for systematic relevance;
4. Studying interactions;
5. Determining a role within the defined system;
6. Examining overall interconnectedness and system dynamics;
7. Weighting preferences and impact of variables;
8. Combing variables to forecast individual scenarios;
9. Evaluating the model;
10. Formulating strategy".

In [31] is discussed the intensive dealing with complexity in business situations; however, a concrete application is left open. Focus is the handling of conflicting objectives, bureaucracy-orientation in the organization and manager's behavior when dealing with complexity [31].

According to [31], situations in business have showed the most common mistakes in dealing with complexity and identified various recommendations for action; the most common mistakes in dealing with complexity are [31]:

- "Unfavorable division of work;
- The illusion of uniqueness;
- The illusion of objectivity;
- Switch off one's head;
- Formalism and bureaucracy;
- Compulsion to control and culture of mistrust;
- Either-or thinking and unresolved dilemmas;
- Neglect of the "*big picture*";
- Uncross linked thinking;
- Application of the "*if-then logic*";
- Unsuitable know-how".

Based on many years of practical experience and the study results published as "*Common mistakes in Management*", a complexity method "*Change®Evolution*" was developed. The method's six steps in detail are the following [31]:

1. "Capturing the current state to target-state discrepancy holistically from multiple perspectives;
2. Analyzing and re-modelling background and objectives;
3. Understanding relationships and areas of tension;
4. Developing design and steering options;
5. Assessing possible troubleshooting issue;
6. Implementation and anchoring of troubleshooting solutions".

2. Specific approach of complexity management (service-related)

The following section describes specific concepts, which have "*service provisioning*" in scope.

According to [20], the researcher combines aspects of complexity theory and application to the public service management. He analyses the complexities within the "*New Public Management*" approach and the challenges and applications of management techniques in the key areas of the public sector, such as performance management, staff development leadership, strategic management and use

of IT. He also examines the relevance of the new theories such as knowledge management, emotional intelligence and risk management in association with complexity management [20].

Furthermore, [4] developed a comprehensive framework for assessing complexity in terms of their cost and benefit effects, in the case of service companies. At the lowest level, the different forms of complexity are described as:

1. Characteristics of service complexity;
2. Manifestations of the complexity of the performance, support and customer processes;
3. Manifestations of employee's complexity. This level affects the middle level "*a result complexity*". This level comprises of the following:
   - Complexity of the performance, support and customer processes;
   - Task complexity;
   - Complexity of the external factor;
   - Technological complexity;
   - Material complexity;
   - Location and branch complexity;
   - Employees complexity;
   - Customers structural complexity;
   - Service complexity;
   - Performance program complexity.

According to [4], the complexity cost and complexity benefit can be derived. The cost elements are subdivided into the following categories: complexity cost planning; cost of documentation; costs of coordination; costs by deviation; opportunity cost of complexity; complexity cost of willingness to perform. The benefits of complexity are divided into three categories: synergies; productivity effects and revenues [4].

The publication [28] discussed how the management and engineering of innovative services with global-distinctive customer in the service sector, can be controlled with the continuously increasing complexity. One possible strategy is to support this strategy through modern technological-oriented service architectures and solutions. The goal is to support the creation and delivery of services in complex processes and relationships through information systems, e.g. web portal. One example is value networks that consist of distributed value chains. These networks can, through the use of complex web portals, connect a large number of participants and roles [28].

3. Special (nonservice-oriented) research areas of complexity management

In the following sections, approaches of the complexity of management, which support specific (but nonservice-oriented) research areas, are analyzed and presented. In [45] is described the research results on the *Generic Model of Complexity (GeMoC)*. The scope of the research is to identify arising problems in collaborative networks. Furthermore, these problems will be linked with different system characteristics (e.g. network structure, trust, degree of commitment, coordination, change, and more). The GeMoC model approach is based on the following complexity drivers (explanations from [45]):

- Uncertainty (e.g. limited information);
- Dynamics (e.g. sudden or constant change);
- Multiplicity (e.g. a large number of participating elements and influence factors);
- Variety (e.g. many types of elements);
- Interactions (e.g. communication load);
- Interdependencies (e.g. feedback loops).

The GeMoC model links the 11 identified following complexity-related problems and the twenty-four system characteristics [45]:

1. Interdependencies of the participating organizations;
2. Strategic incompatibilities;
3. Lack of confidence;
4. Culture incompatibility;
5. Heterogeneous customer requirements;
6. The establishment of partnerships;
7. Misunderstanding in communication;
8. Insufficient and inefficient flow of information;
9. Inefficient network management;
10. Inefficient knowledge management;
11. Inefficient process architecture.

The GeMoC model can be used to identify root causes for specific problems arising in complex networks. This can be reached by analyzing the relationship between the problem and the system characteristics, as in Figure 8 [45].

In [35] are analyze the complexities in product design, which are characterized by a steady increase in complexity. The focus of the research is a structural concept; the structures result from the complex interdependencies of system elements. They have developed a method that allows the analysis, control and optimization of complex structures and applicability of cross-domain problems. The proposal of the procedure is shown in Figure 9 [35] published in German and in 2010 in English

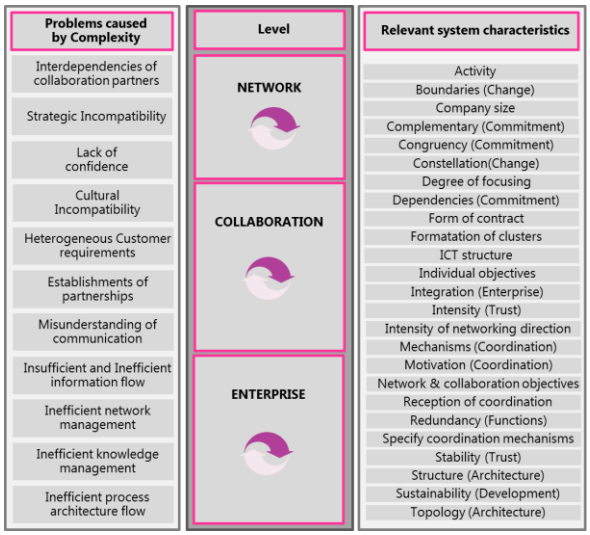

Fig. 8. GeMoC - Generic model for complexity [45]

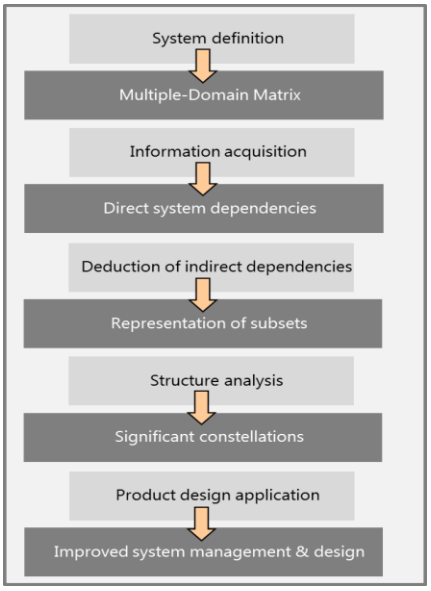

Fig. 9. Procedure of complexity management [35]

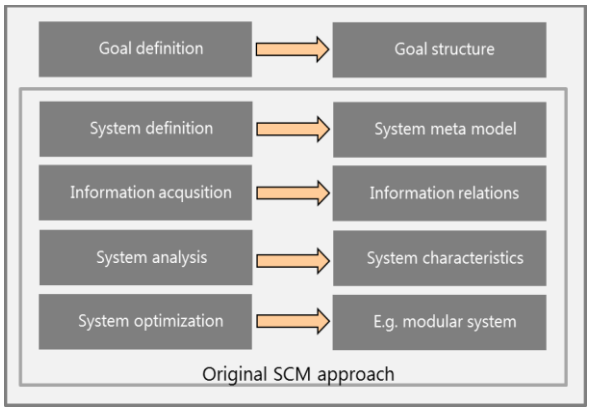

Fig. 10. Structural Complexity Management [11]

Table 2. Process management phases of an integrative approach (derived from [27])

Phases	Description
0	Develop overarching target system for the process landscape
1	Identify processes
2	Define processes
3	Operate and control processes
4	Monitoring Processes

Table 3. Eight patterns procedure (derived from [43])

Pattern number	Description
1	Layout Guidance, to reduce clutter, especially in large process models
2	Layout Split, to transform the existing processes and apply the layout guidelines BPM
3	Group Highlights, to characterize the elements to different groups
4	Graphical Highlights, to highlight certain features and relationships
5	Pictorial Annotation, to strengthen model-specific concepts
6	Textual Annotation, to supplement and add domain-specific information
7	Explicit Presentation, to visualize and distinguish the various ingredients of a process model
8	Naming Guidance, to bring clarity and convey domain-specific information

The approach is based on the *Design Structure Matrix* (DSM) method, which consists of detecting, modelling, analysis and synthesis of interconnection of elements in highly networked systems. Typical examples of such systems are complex and highly integrated product architectures, organizational structures and processes. DSM allows putting in such systems, elements of a kind with respect to the fact that they are connected by a comparable relationship among themselves. As modelling base, a square matrix is used that maps the vertical and transverse axis of the individual elements of the system and each individual cell can be used to map the relationship between two elements. In this case, such a DSM is modelled as "*line has influence on the column*" or "*column affects the line*".

Based on the recent research state, in [11] is presented the concept of *Using Structural Complexity Management for Design Process Driven Modularization*. Starting from a high internal complexity and diversity in most companies, they developed a systematic approach and methodology to modularize a product architecture of the design process view by using the general procedure of structural complexity management. The overall objective is to reduce complexity, cost and product development time in the company and to streamline product architectures through modular design. The approach is based on the *Structural Complexity Management (SCM)* method (Figure 10).

The design process result is presented by the Whitney index (WI), which sets the dependencies of system elements in relationship with their number [11].

In [27] is presented a *model of the integrative process management*, in which were considered the complexities strategies in relation with following concepts: *managing complexity, complexity prevention* and *reduction of complexity*, in connection with the specific process management phases (Table 2). Furthermore, the *process management* instruments mapping is created.

A process-based approach to identify complexities was developed and described in [43], based on the *Business Process Management* (BPM). The proposal incorporates the detection of a broad range of functions required by a collection of patterns. The eight patterns are shown in Table 3.

The work described in [43] provide a systematic analysis of the properties, which are suitable for the management of complex process models in which these properties affect the concrete syntax, but there does not exist a corresponding abstract model. The analysis result provides a form of a collection of patterns and an evaluation of the state-of-art languages. In this pattern-based analysis in process modelling, identified relative strengths and weaknesses in the languages and tools are considered [43].

In 2012, considering the research results of [11], which is a stepwise systematic approach to manage complexity tasks with scope in the product

development process. The stepwise approach includes the following phases: define goal, plan goal, structure goal and define measures. The core of the approach lies in the "*Goal definition*" phase where it is possible to define a number of concrete objectives (derived from each strategy). An example of objectives list could include [11]:

- Optimization of the internal complexity and variety;
- Optimization of the product architecture regarding the actual organizational structure;
- Optimization of the product architecture regarding the actual manufacturing process;
- Highlight the interrelations between development process and product architecture;
- Highlight the communication network within the development process;
- Analyze and highlight of changes' impact on product architecture;
- Thereby, a distinction is made between "*complexity control*" and "*complexity reduction"*.

The paper [12] shows the relationship between products varieties and the complexity increasing phenomena. He focuses on inventory management, using the case of the automobile manufacturers, but companies from other industries, too. The result is summarized as follows [12]:

1. Large range of variants are the strongest complexity drivers;
2. Complexity costs are critical and difficult to assess;
3. Complexity Management is seen as an "*Optimum diversity*" and in this context, the following strategies could be developed: avoid complexity; reduce complexity; master complexity.

The article [44] examined the increasing complexity of companies' business processes. According to their studies, one possible strategy for dealing with the complexity is processes standardization. They analyzed the interactions between standardization effort, business process complexity and business process standardization. They analyzed the hypotheses that the increasing of business process complexity is associated with increasing standardization effort as well as declining business process standardization and that increasing standardization effort is related to increasing business process standardization [44].

For this purpose, a conceptual model was developed and evaluated. The model supports the understanding of the business processes complexity effects on their standardization and the standardization effort to understand and analyze business processes. To test the model hypotheses, a survey of 255 experts was developed in the field of business process management. The results show that business process complexity has a strong positive impact on standardization efforts. In addition, it was clear that increasing standardization effort could not be considered a tool to achieve the standardization of complex business process [44].

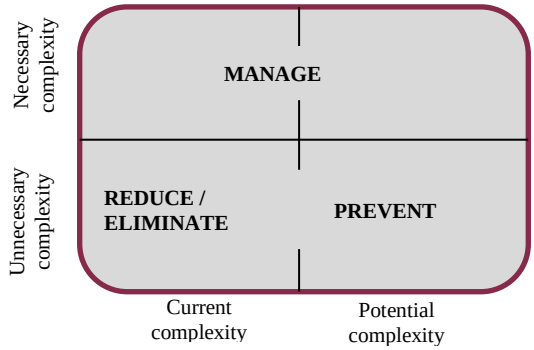

Fig. 11. Matrix of approaches to dealing with complexity [51]

In 2013, the article [19] focus their research on "*Complexity and Robustness Influence on Production Performance - A Theoretical Framework*" in the field of product design and manufacturing by taking into consideration factors as operating, resources, labor and materials. The following variables are defined and integrated into the proposed valuation model [19]: *complexity, stability, flexibility, robustness and performance.*

Furthermore, in [21] is examined the impact of corporate expansion in terms of complexity. Here, the following variables are used: TMT (Top Management Team) growth rate; Common TMT-specific experience; Added product scope; Added cultural distance; Expansion steps; Cultural diversity; Product diversity; Minority; Acquisition; Total ownership; Firm size; Profitability; Capital structure; Slack; Industry mix. These variables are evaluated according to different use cases and then, they are consolidated at different complexity values [21].

In the article [30], researches are focused on organizational development in conjunction with strategic management. Author turns out that the management between *stable* and *unstable* states of a system must be different and he recommended for the unstable systems management the following two strategies for action: (1) trial and error and (2) self-organization [30].

In [51] are presented the results of the study on the complexity drivers in supply chain management where were analyzed the complexity drivers from a temporal perspective (current and potentially) and from the point of whether the complexity is avoidable or unavoidable (Figure 11). The research described in [51] refers to leading researchers in the complexity area, as the studies in [60] and the concept of leading consulting companies was used. According to [51] complexity drives in the supply chain are grouped, by taking into consideration their origin, into the following groups: internal; supply / demand interface; external. Complexity inherent in the supply chain is observed in different forms and origins (Table 3):

- *static complexity*, that is related to the connectivity and structure of the subsystems

involved in the supply chain (e.g. companies, business functions and processes);

- *dynamic complexity*, that results from the operational behavior of the system and its environment;
- *decision-making complexity* that involves both static and dynamic aspects of complexity.

Table 3. Some drivers of supply chain complexity [51]

ACCORDING TO ORIGIN			
Type	***Internal***	***Supply/demand interface***	***External***
Static	– Number/variety of products – Number /variety of processes	– Type of product – Number/variety of suppliers – Number/variety of customers – Process interactions – Conflicting policies	– Changing needs of customers – Changing resource requirements – New technologies
Dynamic	– Lack of control over processes – Process uncertainties – Employee related uncertainties – Unhealthy forecasts / plans	– Lack of process synchronization – Demand amplification – Parallel interactions	– Changes in the geopolitical environment – Shorter product lifecycles – Trends in the market – Market uncertainties – Developments in the future
Decision making	– Organizational structure – Decision making process – IT systems	– Differing and conflicting – Decisions and actions – Non synchronized decision making – Information gaps – Incompatible IT systems	– Changes in the environment – Factors that are out of span of control – Uncertainty of the unknown and uncontrollable factors

More recent, [8] used the three dimensions for analyzing complexities: internal mechanism, environment and co-evolution.

In [18] was described a specific approach (used in military defense) for an innovative procurement process. This uses the PBL (Performance-Based Logistics) model, also known as performance-based life-cycle product support or performance-based contracting, which is a strategy for cost effective weapon system support. Their study is based on five theses for the usability of PBL for the German defense procurement:

1. The procurement of complex service bundles will increase;
2. Efficiency over the life cycle requires the integration of procurement and utilization phase;
3. The increasing importance of incentives as a coordination mechanism for industry;
4. PBL will be procurement alternative to be checked in the future;
5. PBL in numerous projects requires overarching Governance structures.

The core of the research described in [18] approach is given by the contracting for the acquisition, the product support management processes that have to determine the performance increasing of the delivery outcomes, in the case of a system or a product. Thesis one to three and five are incorporated in the further course of this research; reason for this is that the insert is different, but essential features for the use cases fit (e.g., high-voluminous projects, buying complex services, long-term projects, operation management etc.).

Bundesvereinigung Logistik (BVL) Board Annual Report 2014 includes the results of a survey developed with the members' involvement (10,000 members from the top echelons of industry, commerce, services, and science). The report entitled "*Complexity, cost, cooperation*". The analysis of the results shows that "*Industry has learned to deal with complexity*". Complexity management and process optimization are among its main tasks. About 70% of the respondents have recognized that in companies in industry, trade and logistics services have been introduced specific projects for management of complexity. "*Complexity management becomes the drive and pulse generator for process optimization and innovation. Complexity characterizes the logistics sector - efficient management of complexity is therefore a competitive advantage*". In addition, almost 77% of respondents describe structures and processes as complex to very complex. "*It is the diversity of customer requirements and product diversity, leading to more complexity above all in the economic sphere*" [26].

In the article [34] there has been developed a model to analyze consulting firms, complexity-related problem areas and questions based on different *sense-dimensions* (as seen in Figure 12). Each of the dimensions can be characterized from the perspective of the current issues and challenges (with which an organization is facing); the map-based on questions result that is provided by consultants could provide an insight into the events of the company and guide the consulting work, too [34].

The work [55] continue the systems approach for managing complexity in the case of the industrial supply chain. The leading questions of their research are:

- How is a complex supply chain to be evaluated?
- How can we assess the complexities induced by changes of a system?
- How to develop the implementation methods and tools for complexity measurement?

- How to verify the first three questions with industrials cases and thus reduce the non-value added complexity?

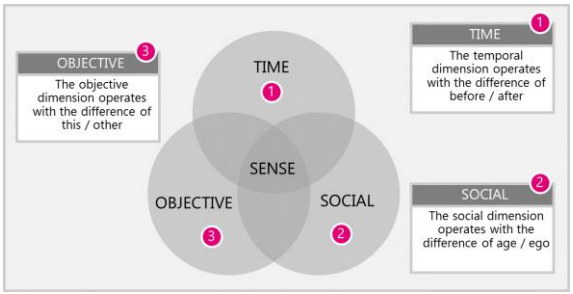

Fig. 12. Model of complexity-related problem areas [34]

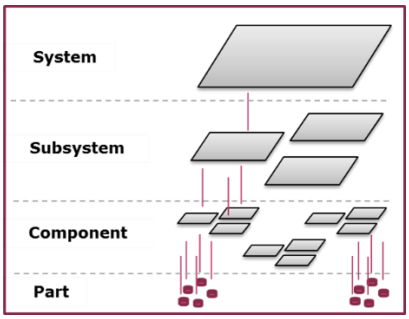

Fig. 13. System decomposition into three layers (figure adapted from [55])

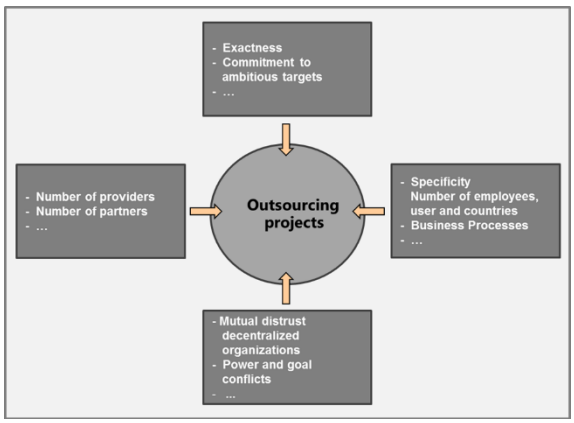

Fig. 14. Complexity factors in Outsourcing [49]

To create a model for complex supply chain, a three-layer architecture was proposed (Figure 13).

For each level, the attributes of basic elements and their interfaces have to be defined. The basic element for the subsystem layer is the subsystem, similarly for the layer of component and part. In the created model, the interfaces are described as the relationships among all the elements. The article [55] employs a conceptual model including the following four elements: process, role, object and its states (PROS), in order to describe a complex system.

4. Complexity in outsourcing projects

In [48] is discussed the topics of complexity, using the example of outsourcing projects. These projects are characterized by unmanageability, opacity, networked, intrinsically dynamic, severe predictability of the consequences, politely; there has been emphasized three possibilities to deal with complexity by: (1) avoiding complexity; (2) reduce complexity; (3) the ability to manage complexity. Furthermore, [49] work notes that the level of complexity mainly depends on the nature and extent of the outsourced functions (Figure 14). In addition, internal resistances, especially for projects with staff transition, impede the course of the project [49]. Because of many debates, in [49, 50] there is noted that complexity in outsourcing can be limited as follows:

- Reduce the scope of the project;
- Building confidence and do not move rules or processes in the foreground;
- Set clear steps within the organization that are precisely defined and fixed by contract;
- Involving external know-how;
- Only set realistic goals;
- As a prerequisite for the outsourcing process, clear, identifiable structures and processes are set up.

In the article [50] there has been analyzed the dimensions of the negotiation process from the perspective of the service provider. Both researchers have worked out on the various incentives and motivations behind their actions of the parties and provide concrete negotiation strategies to avoid projects complexity. A relevant key message was that the contract cannot cover all the options and therefore a way must be found to cover a corresponding flexibility of future-oriented uncertainties. Another statement was that the contractual arrangements will often be given too much importance and this is a bad start for the future of supply and services relationship [50]. In addition, there have been presented ten propositions, in which he reaffirmed: outsourcing is complex. The impacts of complexity are not reflected enough [50].

In 2014, the Project Management Institute (PMI) has published a book about how to navigate with complexity. PMI pointed out that complexity in programmes and projects will always be existent. However, globalization, new technologies, and fragmented supply chains have significantly increased and compounded the complexity situations that practitioners are confronted with. Faced with objectives that are more challenging and a higher percentage of their budgets at risk due to complexity, business leaders realize the critical need for successful delivery of these unique programmes and projects. As a result, there have been a variety of studies and publications on complexity, but few of them are focus on providing practical approaches [40]. For navigating complexity, the „*Practice Guide*" provides methods in order to effectively manage complexity in programmes and projects, in the following six sections:

- Organizational Considerations;
- Encountering Complexity;

- PMI Foundational Standards and Useful Practices;
- Navigating Complexity: The Assessment Questionnaire;
- Complexity Scenarios and Possible Actions;
- Developing the Action Plan.

PMI has formed three main categories of complexity for the control of programmes and projects: Human behavior; System behavior; Ambiguity [41].

In the last years, in the field of Project management the need has arisen for an intelligent and fundamental strategy to address the challenge of dealing with complexity [9].

According to [17] there have been identified key issues for a successful outsourcing project: dealing with uncertainty and importance of mutual trust relationship. Besides the importance of trust, dealing with the uncertainties in outsourcing projects has been recognized as a very important aspect. In [17] there are described these aspects (only) on a very high level. In addition, it has been worked out that all the parties involved in an outsourcing projects are trying to maximize their benefits during the project development. The first package of measures recommended has been the consideration of uncertainties in the pricing models. Second, it has been recommended that the parties' behavior have to be evaluated permanently through a third company [17].

Although *outsourcing process* was intensively studied in recent years, together with its impact on organizational aspects that is still not very well understood [2].

III. CONCLUSION

Many of the concepts are aimed at the assessment and the mastery of individual complex situations rather than on long-term complex situations in an overall context, e.g. *Seven Steps in the intuitive handling of complexity*. The concept *Managing Process Model Complexity via Concrete Syntax Modifications* focuses on the representation of the processes and the contained complexities. In [48, 49] were analyzed complexity in outsourcing situations for the first time in 2007 and recommends three strategies and derived theses to deal with the complexity. These researches analyze the causes of complexity trap in the case of outsourcing project and derives complexity factors. Furthermore, practical guidelines on how complexity can be limited are given. These recommendations are partially inconsistent with other researchers in this research field. For example, it is known that the complexity of the company itself is a trigger for an outsourcing project. However, the above mention works recommend the creation of clear structures in the run-up to the project. The research results are of the few that bring the complexity of management with outsourcing projects systematically together. A scientific universal model for use in large-scale projects is not provided.

In the research [7] was developed eight strategies, which are gradually performed one after the other. The view and the examples shown relate to the industrial production of products. With the aid of production-related classification, complexity should be manageable. Simulation modelling support that the company will be able to prepare for future challenges. The *Generic model for complexity* described in [45] can be regarded as the standard model in the management of complexity from a perspective of collaboration. A derivation of management strategies, scenario building and recommendations for practice are not included in the model. The empirical study named: "*The influence of complexity to the standardization of business processes"* described in [44] analyses the standardization strategy in dealing with complexity in business processes. The focusing of the study and the development of a model assesses the relationship of this complexity strategy. An extension of the perspective on external corporate networks would be an interesting perspective to include the internal and external view of a company. The work included in [14] focuses on the management under uncertain environments and proposes a procedure model for dealing with complexity. In addition, it provides general recommendations for action at the highest strategic level. Furthermore, it is using a global view and focuses on human action behavior in management. The relevant research included in [53] in based on a derivation of a model for dealing with complexities, which is based on safety, uncertainty and indefiniteness. They specify requirements for a model and apply these to manage technology in a holistic view (also to apply for outsourcing situations). Specific models for the management of complexity in business are not pronounced. The work described in [13], analyses the reasons of complexity and recommends (like other researchers also) complexities through networks to capture and to make transparent. The focus is on the border of complexities to chaos. In [40], PMI published "Practical guide", therewith creating a new standard approach for the first time in science (besides the research from [48, 49] for Outsourcing projects), where complexity management and projects / programmes are linked with each other. The practical analyses and concepts included in [60] are very extensive and all-encompassing: they relate to functional blocks in the company. Despite the fact that a specific reference to provision of services is lacking, the approach described in [60] will be of relevance in the context of the future managing complexity model development.

The science of complexity management significantly existed only in the last 10 years. Moreover, it should be noted that (due to the interdisciplinary) a wide variety of research approaches exist. It can be observed that a variety of concepts in the past three years include similar structures, for example, the necessary internal and external view of complexities. It must also be noted that a variety of models have got a "*decision making-character*". In the

context of long-term (outsourcing) projects, the time perspective must be considered. Exclusively a literature of 2014 uses the terminology: „navigating complexity". In the systematic approach with environmental focus presented in the article [24], external factors are adequately sufficiently taken into account. In outsourcing relationships, also external factors are of great relevance and therefore the content to be taken into account in this research.

The approach provided by [31] is very extensive and refers to the management of complexities in the business environment. The steps in the recommended procedure are extensively enriched with a variety of different management tools. This is what the strong interdisciplinary nature of complexity management needs. A modification of projects for major customers, such as large-scale outsourcing is not given.

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A Study on Identifying the eCommerce Players and Business Model

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Abstract – The aim of the paper is to analyze the eCommerce industry development in order to create the theoretical base for the business valuation process, in the case of the eCommerce industry (particularly refer to the online retail industry). Considering this research approach, the most important part of a valuation base and drivers analysis is to identify the relevant companies and by a detailed understanding of their business model, to recognize which companies can be compared to each other. The presented study's conclusions will underline important issues for the companies' valuation process.
Keywords: eCommerce, industry, analysis, drivers, business model, retail, marketplace.

I. INTRODUCTION

1. Brief history of the e-commerce industry

In addition to being an important new distribution channel for businesses [56] with a global target audience, compared to a local one in traditional retail, and proving convince and transparency to consumers [5], the eCommerce industry represents an interesting case study of an industry which developed to reach a certain level of maturity in less than 30 years by taking fully advantage of a new technology, the Internet.

The first eCommerce transaction happened back in the early 1970s, when students using ARPANET accounts at Stanford University "*engaged in a commercial transaction with their counterparts at Massachussetts Institute of Technology*" [32]. Ironically, "*students used the network to quietly arrange the sale of an undetermined amount of marijuana*" [32, 39]. ARPANET was the precursor the Internet, developed by the United States Advanced Research Projects Agency (ARPA), and initially involved connecting four universities with the aim of sharing computer resources [42]. The electronic exchange of information in the 1970s was facilitated by the development of the Electronic Data Interchange (EDI) in the 1960s by the United States transportation industry. As the name says, the EDI facilitated the electronic exchange of information between different computer systems, replacing the traditional way of mailing and faxing of documents employed until then by trading partners [34, 53].

The predecessor of today's consumer focused eCommerce was the TV and telephone shopping system invented by Michael Aldrich, and English inventor and entrepreneur in 1979 [34, 51]. His invention consisted of a modified television which was connected via the telephone line to a real-time multi-user computer capable of processing transactions. The system was mainly sold to businesses to be used for Business-to-Business (B2B) transactions [51].

In 1981, Thomson Holidays UK was the first B2B online shopping system to be installed and to go live. In 1982, Minitel, the predecessor of the Internet connected computer was introduced in France. Minitel allowed the users to use online banking and book travel reservations via phone lines. 9 million devices were installed in France, with an estimated 25 million users [44].

The first B2C online shopping system, the Gateshead SIS/Tesco, became active in 1984 with the first order being placed May 1984 [6, 61]. In April 1984, CompuServe launched the first comprehensive eCommerce service in the United States and Canada, the Electronic Mall [37].

In 1987, SWREG (nowadays part of Digital River MyCommerce) was founded and represented the first electronic store for software [40]. In 1989, Peapod, the first online grocery store and the world's first e-commerce only company launched [38].

Another very important technical development which enabled the online commerce as we know it was the first web browser developed by Tim Berners-Lee on a NeXT computer in 1990, called WorldWideWeb [55]. Later the browser was renamed Nexus in order to avoid confusion with the information space called the "*World Wide Web*". **Error! Reference source not found.**] shows the first web browser.

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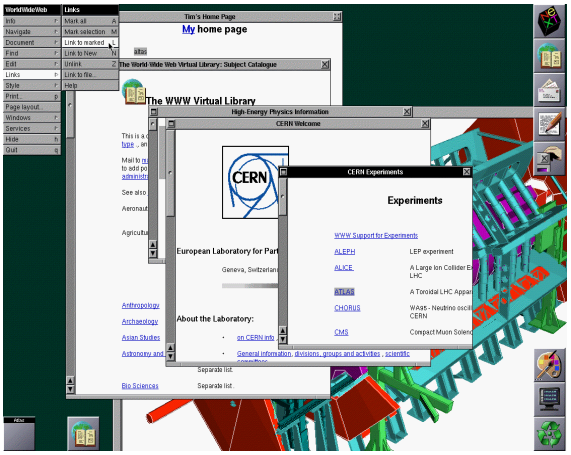

Fig. 1. The WorldWideWeb [55]

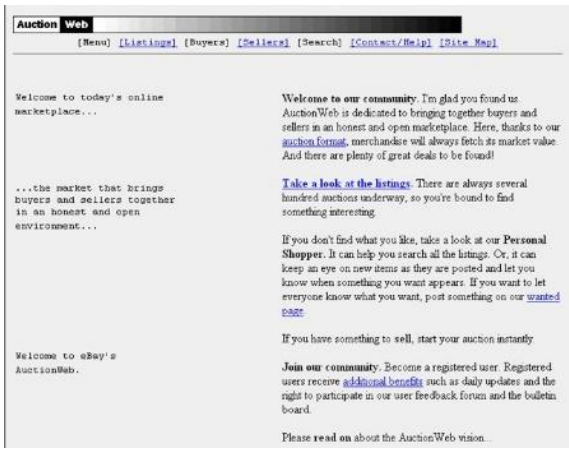

Fig. 2. ebay.com in 1995 [50]

Fig. 3. amazon.com in 1995 [4, 54]

In 1992, Charles Stack, a lawyer who became a software developer opened the first online book store, Books Stack Unlimited (www.books.com), 3 years before Jeff Bezos launched Amazon.com [54]. In 1994, Netscape released the Navigator web browser which supported HTML 2 functionalities and some HTML 3 functionalities [8]. Furthermore, Netscape adopted the Secure Sockets Layer (SSL) protocol which enabled a way of transmitting information over the Internet in a secured way and hence enabled the processing of transactions over the Internet [13].

In 1994, Ipswitch IMail Server becomes the first software to be sold online as well as the first software to be delivered via the Internet, fact which was enabled by a partnership between Ipswitch and OpenMarket [22]. The following year, many traditional retailer such as WHSmith [58] and Interflora [20] launched their online shopping services. In the same year, Stanford Federal Credit Union became the first financial institution to offer online financial services [49].

In 1995, Jeff Mezos launched Amazon [4] and Pierre Omidyar launched AuctionWeb [19], renamed later to eBay, two of the companies which later shaped the eCommerce industry. Even though, these two companies have significantly extended their business model over time, the business model with which they started were significantly different. While Amazon was happy to take over inventory risk, eBay was from the beginning an auction website that acted as a platform between individuals willing to exchange or sell / buy goods. These two different business models are still very relevant today, as companies assuming inventory risk are looked at as retails while marketplaces are looked at as a platform.

Fig. 22 and Figure 3 show Amazon's and ebay's websites in 1995 and implicitly the very simple offering that started an entire eCommerce revolution.

In 1999, Alibaba, the global wholesale marketplace was established by its 18 founders, led by Jack Ma. During the same year, the company launched a China based marketplace (known as 1688.com) addressing the Chinese domestic market. During the same year, Alibaba managed to raise USD 5m from a group of investors [2]. Nowadays, having surpassed even Walmart, Alibaba has become the largest retail company in the world with yearly gross merchandise value of nearly USD 500bn [11].

Following the early successes of many eCommerce companies, many entrepreneurs and investors rushed into this industry and hence created the "*dot-com*" bubble [48]. Two of the largest and most well-known companies that went bankrupt during the dot-com bubble are Pets.com and Webvan. Pets.com was an online pet food and supplies retailer, while Webvan was an online grocery retailer [16]. Both companies failed because of their efforts to grow very quickly and absorb a large market share by running deep losses. Pets.com received a total funding of c. USD 300m [52] while Webvan raised during the IPO alone USD 375m [57]. To understand how absurd some of these companies were valued, it is useful to look at the Webvan IPO which after the first day of trading was valued at c. USB 6bn despite having less than USD 5m in revenue [47].

Following the dot-com bubble, investors were more sceptic of the potential of eCommerce companies and these in turn were forced to show profits. Alibaba for example became cash flow positive for the year in December 2002 [2] while Amazon posted the first yearly profits in 2014, for the year 2013 [60].

Despite the dot-com bubble causing a significant skepticism in the eCommerce market, many additional

well-known eCommerce shops such as Groupon in 2008 [17, 18] and Zulily in 2010 [36] launched over the following years. Furthermore, the industry started to consolidate with many sizable acquisitions, e.g.:

- In July 2009, Amazon acquired Zappos, an online shoe retailer, for USD 928m with the ultimate goal to share know-how [27];
- In November 2010, Amazon acquired Diapers.com (and other companies part of Quidsi), an online baby focused retailer, for USD 540m [45];
- In January 2007, eBay acquired StubHub, a marketplace for event tickets, for USD 310m [7].

2. The size and development of the ecommerce industry

Nowadays, the eCommerce industry comprises 650,000 online stores (only including the ones generating annual sales of over USD 1,000) [41] or 110,000 (including only the ones "*generating revenue of meaningful scale*") [35] depending on which source is consulted and sales of over USD 1.6 trillion [12] highlighting the importance of the industry. Figures 4 and Figure 5 show the size and expected development of the eCommernce industry until 2019. eMarketer expects the overall global eCommerce market (excludes travel and event tickets) to surpass USD 2tn in 2016. By 2019, the industry is expected to surpass USD 3.5tn.

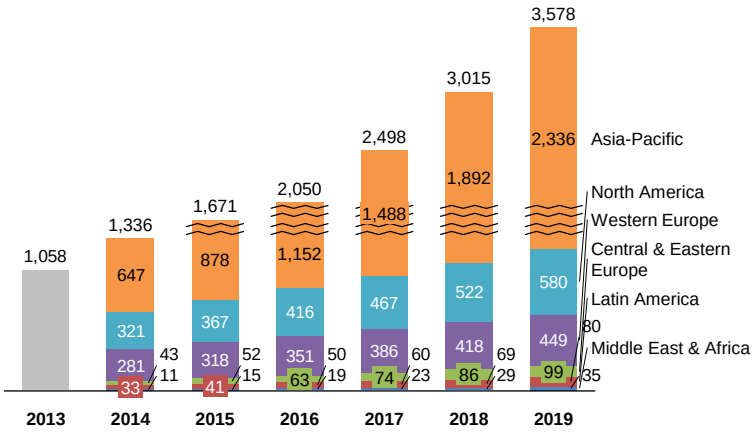

Fig. 4. Retail eCommerce sales by region in USD bn [12]

Growth rates by region

2014	2015	2016	2017	2018	2019	
	36%	31%	29%	27%	23%	Asia-Pacific
	14%	13%	12%	12%	11%	North America
	13%	11%	10%	8%	7%	Western Europe
	23%	19%	18%	16%	15%	Central & Eastern Eur.
	23%	22%	20%	15%	16%	Latin America
	28%	27%	25%	23%	21%	Middle East & Africa
26%	25%	23%	22%	21%	19%	Total

Region share

2014	2015	2016	2017	2018	2019	
48%	53%	56%	60%	63%	65%	Asia-Pacific
24%	22%	20%	19%	17%	16%	North America
21%	19%	17%	15%	14%	13%	Western Europe
3%	3%	3%	3%	3%	3%	Central & Eastern Eur.
2%	2%	2%	2%	2%	2%	Latin America
1%	1%	1%	1%	1%	1%	Middle East & Africa
100%	100%	100%	100%	100%	100%	Total

Fig. 5. Retail eCommerce sales growth rates by region and region shares [12]

When analyzing the geographical split of the global eCommerce industry, one can see that the Asia-Pacific region already makes up for over 50% of the industry. Furthermore, due to overproportioned growth this region will represent 65% of the entire industry by 2019. When comparing growth rates, one can see that Asia-Pacific is growing with a growth rate of nearly 30% per annum over this period, while other regions that represented the key eCommerce markets in the past, North American and Western Europe, are growing with 10 to 13% per annum, with Western Europe's growth rate dipping to 7% in 2019. These trends will not only shape the future of the eCommerce industry, but need to be kept in mind while analyzing the valuation basis and drivers of the eCommerce industry, as different growth prospects across geographies can yield different results.

To fully understand the size and importance of the eCommerce industry, it helps to compare it with the overall size of the total retail industry as well as to look at the number of digital buyers that are purchasing online.

When looking at the retail industry as whole, one can observe that in 2015, eCommerce accounted only

for 7.4% of the retail industry, however, it is expected that it will make up nearly 13% of the overall retail industry by 2019. This enormous development comes primarily from an unproportioned growth of the eCommerce industry compared to the entire retail industry. The eCommerce industry is expected to grow between 2016 and 2019 on average 21.0% per annum, while the entire retail industry (including eCommerce) is expected to grow on average 5.5% per annum. The "*other channels*" portion of the retail industry, mainly store sales, is expected to grow at an average of 4.0% with a minimum expected growth rate in 2019 of 3.6%. These figures not only show the overall importance of the eCommerce industry, but also the growing importance relative to the retail industry as a whole. It also shows that the preferred channels over which people buy switch from the traditional retail to the online retail. Fig. 6 shows a quick overview of the mentioned figures.

Furthermore, when analyzing the total number of digital buyers (number of people that buy online), once can see huge increase over the coming years. The total number of buyer is expected to grow from nearly 1.5bn in 2015 to nearly 2.1bn in 2016, an increase of c. 600m additional buyers. To put this number in perspective, it is useful to compare it to the entire population of the entire European Union, which is only c. 500m people according to latest Eurostat statistics. In addition to the growing number of online shoppers, the average amounts spent by these shopper is also expected to grow significantly from USD 1,143 in 2015 to USD 1,730 in 2019, highlighting the willingness of shoppers to purchase more and more online compared to other channels. Fig.7 shows a quick overview of the total global number of digital buyers and the global average sales per buyer.

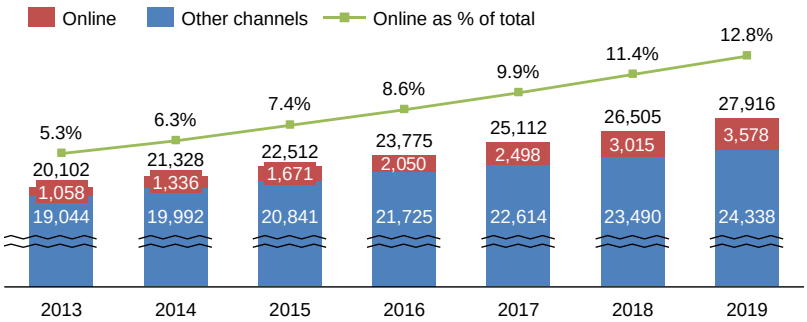

Fig. 6. Total retail sales worldwide by channel [12]

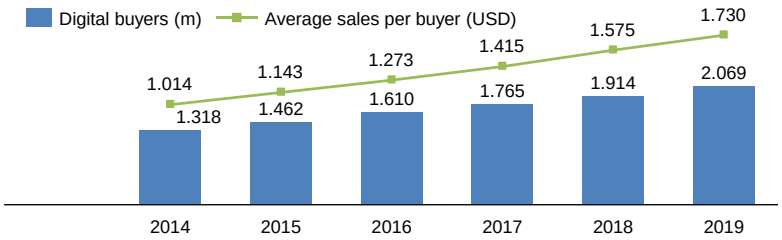

Fig. 7. Total number of digital buyers and average sales per buyer [12]

Overall, the growing importance of the eCommerce industry is undisputed, however, the decreasing growth rates give away the fact that the industry is approaching a certain level of maturity. As industries mature, the valuation basis and drivers of companies in this industry are also expected to shift. Generally, as an industry matures, profitability is becoming increasingly important for investors and hence the valuation basis and drivers also should go in this direction.

3. Overview of some reasons for increasing the importance of the eCommerce industry

According to a study done by the Susan Lee in 2013, the three pillars which helped eCommerce reach its current state are: low prices, technology and bottom up experiments [30]. Lee not only acknowledges the level of maturity that the industry has achieved, but also explains how these pillars will change in the foreseeable future and makes a few recommendations.

Lee tackles the first pillar by saying that "*low prices played a key role in establishing online brands and accelerating market penetration, but they have also left retailers with an oversimplified value proposition: 'price, price, price'*" and suggests that in the future retailers might have to reconsider their value proposition (such as free shipping) compared to just offering the best price as market demands are changing [30].

The statement might imply that some of the price pressure experienced by most eCommerce players today might partially be lifted in the future helping implicitly margins. From a valuation perspective this trend favors very large players like Amazon which "*enjoys economies of scale far beyond […] online*

competition" [23] as they can achieve significant economies of scale while expanding their overall offer.

An important aspect which should also be taken in account when comparing a price focused strategy with a value proposition strategy is the extreme price transparency in eCommerce. Today, with the help of the price comparison websites, it is very simple to compare prices across many online shops. The online retail industry faces previously unseen level of price transparency. While buyers will likely buy from knowns online shops, having a significantly higher price will likely deter the buyer to a competitor.

A study done by the company Blackhawk Engagement Solutions concluded among others that "*price has the greatest influence on millennials' purchase decisions above all other factors, including quality, brand, store and availability*" [15]. Price sensitivity translates in the valuation of eCommerce companies in the classic growth / profitability trade-off. By offering lower prices, an online retailer can grow relatively easily, however, it will be less profitable. On the other side, higher prices improve profitability at the cost of achieving less growth and usually also giving up market share.

The second and third pillars are addressed by Lee with the explanation that "*it's about selling, not technological sophistication*" and "*it's about top down transformation, not bottom-up experimentation*" [30] implying that the eCommerce industry will have to embrace the key typical skill of traditional brick-and-mortar stores of focusing on selling products rather than continuously focusing on improving their technology and that retailers need to embrace these changes from the top of the company instead of just focusing on small improvements.

Despite the importance of these pillars and transformations, they can be difficulty incorporated in eCommerce valuation trends. In addition to the already mentioned pillars, Timothy Laseter and Elliot Rabinovich describe two additional ones in their book "*Internet Retail Operations*".

These two additional pillars are convenience and selection [28]. While these two additional pillars are implied by Lee's value proposition pillars, they are worth mentioning as both have tremendously helped building up the eCommerce industry. Amazon for example has built up its initial business on the long-tail offering of books (very high selection) and convenience (continuous focus on fast delivery times and other convenience items like "*one-click*" ordering)

II. THE RESEARCH APPROACH ON IDENTIFYING ECOMMERCE PLAYERS AND BUSINESS MODELS

In this chapter there will be created the theoretical base for the business valuation process, in the case of the eCommerce industry (particularly refer to the online retail industry). Considering this research objective (for the future approaches), the most important part of a valuation base and drivers analysis is to identify the relevant companies and by a detailed understanding of their business model, to recognize which companies can be compared to each other. Those companies need to operate in the same industry, face similar trends and market environment, as well as use similar account standards and practices.

1. Companies included in the study

The goal of the presented study is to cover all publicly listed companies in the goods based eCommerce industry, independently of the particular business model of the individual companies and their dominant geography. Consequently, traditional generalist players as well as well as focused players and players generating commission as opposed to revenues are included.

The further segmentation of the companies into inventory based companies and platform based companies will happen at a later stage. The goal of this section is to identify all relevant eCommerce players independently of business model or data availability and relevance. In order to ensure that all relevant companies are identified, a wide range of sources have been consulted:

- *FactSet*: a financial information database offered by FactSet Research Systems Inc. based in Norwalk, United States. The database offers financial information and analytical software for investment professionals [14] and is one the four comprehensive databases available worldwide. In order to find relevant companies, the general and universal screening function has been used together with relevant industry filters;
- *Altium Digital, Media & Internet Monitor from Q1 2016*: This a publication of Altium Capital, a German M&A Advisor which offers on a quarterly basis and update on the "*global market data, sector valuation and M&A activity*" [3];
- *William Blair Internet & Digital Media Insights from January 2015*: Similarly to the Altium Digital, Media & Internet Monitor, this publication offers "*overview, analysis, and trends in the Internet & digital media industry*" [59];
- *The 2014 Top 500 Online Retailers Guide* published by Internet Retailer, a well-regarded industry publisher that publishes yearly reports on the global and regional eCommerce markets [21];
- A wide range of own presentations, analyses and valuations prepared over the last 5 years.

In Appendix 1 is shown an overview of all companies included in the study, the year of incorporation, the country of the headquarters as well as a short description of the business.

After identifying and briefly understanding all companies within eCommerce environment, it is

important to determine which companies can be compared with each other by analyzing their business model in detail.

2. Company segmentation and comparability

a. eCommerce business models: Traditional segmentations

In order to understand the best way of segmenting companies, it is important to firstly understand the typical business models in eCommerce. The traditional ways of classifying eCommerce companies are based on the type of goods sold and on the nature of the participants [24]. As nowadays there a limited number of pure-play shops focusing only one type of goods (excluding fashion shops) the classification by types of goods loses its relevance. The second traditional classification, the one based on the nature of the participants is still relevant, however, even in this case the historically clearly defined boarders are fading away as more businesses are entering different models. Amazon is very good example of a company that started in the Business-to-Consumer segment and increasingly became a platform which enables other businesses to sell to consumers as well.

The classification of eCommerce companies by the nature of the participants is presented in the following (see details in Table 1):

- *Business to Business eCommerce (B2B)*: a type of eCommerce in which a company sells to another company goods and services which the buying company uses to produces other goods and services. The drivers and key application of B2B eCommerce are: procurement optimization, partner management and order fulfillment [26]. In eCommerce, the concept of B2B is often used together with the concept of lead generation [31]. One of the first companies that monetized this type of business was Alibaba which was helping Chinese manufacturers to sell their products to foreign buyers.
- *Business to Consumer eCommerce (B2C):* a type of business in which a business sells goods and services directly to the end consumer. This is the most common type of eCommerce for the average online buyer. Usually eCommerce is used as a synonym with B2C eCommerce. This type of eCommerce is also very comparable to the traditional retail industry in which a customer would enter a physical shop in order to buy a good or a service.
- *Consumer to Business eCommerce (C2B):* a type of business in which consumers sell products and services to businesses. Despite this type of eCommerce business sounding counterintuitive, the Internet has enabled consumers to explain businesses what type of goods and services they would like to purchase and allows business to bid for the "*business*" [24]. A few examples include freelancing websites such as TaskRabbit, where the end-user posts jobs that he needs to fulfilled, job-boards where the future employee posts its credentials and allows companies to "*bid*" for his services or "*cash for gold*" type business in which consumers sells its products (gold) to a business in order to enable the business to use it and make money as well [31].
- *Consumer to Consumer eCommerce (C2C):* a type of business in which consumers sell to other consumers products and services. In this case the online retails acts only as a platform between consumers. The example which most often comes in mind when discussing this type of eCommerce is eBay. eBay is sometimes also called a C2B2C type of eCommerce (Consumer to Business to Consumer) [24]. Dating platforms or websites like Etsy which enables consumers to sell own produced goods could also be regarded as examples of C2C eCommerce [31].

One type of eCommerce that is not covered in this classification and that is becoming increasingly relevant is *B2B2C Ecommerce (Business to Business to Consumer).* This type of eCommerce is strongly linked with the increasing attractiveness of marketplaces. The platform provider or the first B, is hoping to acquire more customers at once rather than acquiring individual customers while providing services to an intermediate B (middle B) [25].

The platform provided by the first B is built to be consumer friendly and ultimately targets consumers. This type of eCommerce, can be compared to the healthcare industry which provide marketing materials and samples to doctors (intermediate B) in order to ultimately sell their products to the end consumer [10]. The company that deliberately developed this type eCommerce, and is well known for its B2B2C business model is Rakuten. Rakuten is providing a type of virtual Mall in which resellers can sell their products via own shop-in-shops. Furthermore, Rakuten's business model has not stopped with the development of the platform and also started offering consumer finance and payment services [62].

A very structured and modern, however, very theoretical eCommerce business model segmentation is provided by Laudon and Traver in their Textbook "*E-Commerce 20*14" where they segment eCommerce business in "*B2C business models*", "*B2B business models*" and "*business models in emerging e-commerce areas*" and then further segment the categories in numerous sub-categories [29]. It is important, however, to notice that Laudon and Traver's definition of eCommerce is significantly farther reaching and is fairly synonym with the wider term of online business rather than retail-like eCommerce. It also includes many categories which arguably are too remote from eCommerce in order to be included in such as a classification.

Table 1. eCommerce business models (synthesis from [29])

Model	***Variation***	***Example***	***Description***	***Revenue model***
B2C Business Models				
Portal	Horizontal/ General	Yahoo	Integrated package of content and content-search (e.g. news, e-mail, music, video)	Advertising, subscriptions, transaction fees
	Vertical/ Specialized	Sailnet	Services and products to specialized marketplaces, focused on product groups	Advertising, subscriptions, transaction fees
	Search	Google	Focuses on offering search services	Advertising, affiliate referral
E-tailer	Virtual Merchant	Amazon	Online version of retail store	Sales of goods
	Bricks-and-Clicks	Walmart.com	Online distribution channel for a company that also has physical stores	Sales of goods
	Catalogue Merchant	LLBean.com	Online version of direct mail catalogue	Sales of goods
	Manufacturer-Direct	Dell.com	Manufacturer uses online channel to sell direct to customer	Sales of goods
Content Provider		WSJ.com CNN.com	Information and entertainment providers such as newspapers and sports sites, and other online sources	Advertising, subscriptions, affiliate referral fees
Transaction Broker		E*Trade Expedia	Processors of online sales transactions, such as stockbrokers and travel agents	Transaction fees
Market Creator		eBay Priceline	Businesses using the Internet to create markets bringing buyers and sellers together	Transaction fees
Service Provider		VisaNow.com	Companies selling a service, rather than a product	Sales of services
Community Provider		Facebook, Twitter	Sites where individuals with common interests (or social) networks can come together and "*meet*" online	Advertising, subscription, affiliate referral fees
B2B Business Models - Net Marketplace				
E-distributor		Grainger.com	Online version of retail and wholesale store, supply maintenance, repair, operation goods	Sales of goods
E-procurement		Ariba Perfect Comm.	Creator of digital markets where sellers and buyers transact for indirect inputs	Market-making fees; SCM and fulfilment services
Exchange		OceanConnect ChemConnect	Independently owned vertical digital marketplace for direct inputs	Transaction fees
Industry Consortium		Exostar, Quadrem	Industry-owned vertical digital market open to select suppliers	Transaction fees
B2B Business Models - Private Industrial Network				
Single Firm		Wal-Mart	Company-owned network that coordinates supply chains with a limited set of partners	Cost supported by owner in exchange for efficiencies
Industry-wide		1 SYNC Agentrics	Industry-owned network that sets standards, coordinates supply and logistics	Cost supported by owner in exchange for efficiencies
Business models in emerging eCommerce areas				
Consumer-to-consumer		eBay	Helps consumers connect with other consumers to conduct business	Transaction fees
Peer-to-peer		The Pirate Bay	Technology enabling consumers to share files and services online	Subscriptions, advertising, transaction fees
M-commerce		eBay Mobile, PayPal, Mobile	Extending business applications using wireless technology	Sales of goods and services

Laudon and Traver's eCommerce business segmentation has arguably also a few short comings and incompatibilities regarding the overall industry definitions, the companies included and their clustering which need to be analyzed before using this model as an input for the own developed segmentation of the eCommerce companies. The following short comings have been identified:

Overall eCommerce definition: Laudon and Traver use a very wide reaching definition of eCommerce which contrary to perceiving eCommerce as a purely online retail of goods and services industry perceives it as the wider reaching term of online business which often also includes the online portion of other industries such as online banking and software that uses the Internet as a medium of exchange of information. While this wider definition is not incorrect, it is only to an extent compatible with the goal of the study of analyzing online retailers

Inclusion of arguably unrelated categories: The model includes categories such as eProcurement, single firm and industry wide industrial private networks and peer-to-peer exchanges. While the eProcurement industry uses the Internet as medium of exchange of information, and sometimes also helps initiate or settle transactions, it is usually regarded as a software solution and is usually analyzed together with software peers instead of eCommerce peers (e.g. Enterprise Resources Planning software, Supply Chain Management software, Spent Management software, Product Life Cycle Management software). While the examples provided are correct: Ariba and Perfect Commerce, they only confirm the impartibility. A similar argument can be made for the single firm and industry wide industrial private networks. While these networks can facilitate transactions, they are usually software solutions. Last but not least, the inclusion of peer-to-peer exchanges is odd, particularly with the example The Pirate Bay, as these networks usually do not generate significant revenues for any of the parties. Networks such as Usenet, which generates revenues, should be regarded as B2C service as the files are centrally hosted and users pay to certain company a usage fee in order to gain access to these files

Exclusion of certain related categories: Considering that the authors have used a fairly wide-reaching definition, and included categories such as eProcurement and Private Industrial Networks, other categories with similar distribution models (via Internet) should have been included. Most eProcurement companies use a Software as a Service (SaaS) delivery model implying that all other SaaS providers should have been included. SaaS is at the end of the day a sale of a service via the Internet. Furthermore, other categories such as online banking and payment providers which have become over time a stand-alone industry were excluded. While it could be argued that they are included under "*Transaction Broker*", they represent a completely different service compared to online stock brokers and online booking agencies and face completely unrelated competitive environments and supply chain dynamics. Another example of a segment that has been excluded is the B2B2C segment (discussed earlier in the chapter) which is arguably different that both B2B and B2C eCommerce business model.

Treating C2C models and mCommerce models as emerging eCommerce areas: The C2C based eCommerce model existed for as long as most of the other categories and started with the incorporation of eBay in 1995. Hence, this model is far away from being emerging. Last but not least, mCommerce, in addition to have also existed for long time, it is nowadays part of each of the other categories. Most online businesses, independently if they are selling goods, services or simply providing content have a well-defined mobile strategy and a fast growing mobile audience.

b. eCommerce business models: Retailer vs. Marketplace

While analyzing the various classifications of eCommerce business models, one can observe that a separation made consistently is the one between classical B2C business model and marketplaces / platforms. When applying this idea to the companies on which this study is focusing – online retailing businesses – it is very clear that the very top level segmentation needs to be between companies that assume inventory risk and companies that do not assume inventory risk.

The segmentation based on inventory risk is also motivated by the different accounting standards applicable to the Internet retailers compared to marketplaces. The main difference between the applicable accounting standards is based in the different revenue recognition methods [33]. While today, the international accounting standard board and other important local accounting regulation bodies have defined clear guidelines regarding what can be recognized as revenue, historically, companies had a lot more flexibility regarding this.

During the previously mentioned dot com bubble, as companies where trying to raise money to finance growth, valuations were purely based on revenues as all eCommerce companies were still loss-making. In order to receive the highest possible valuation, many eCommerce companies – including some marketplaces – were trying to report the highest possible revenues [46]. Hence, many marketplaces, despite not actually owning the item being sold and acting only as a match-maker, were reporting as revenue the total value of the product being sold or gross revenue (Gross Merchandise Value) as revenue.

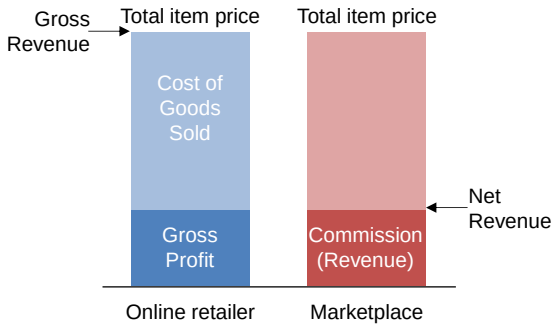

Fig. 8. Revenue recognition [33]

Fig. 88 shows at a glance the difference between gross and net revenue. Gross revenue is defined as "*the income generated by a company through sales of*

goods, without any kind of deduction taken into consideration" while the net revenue is "*used to define a commission-only revenue model*" [33]. Online retailers report gross revenue as revenue wile marketplaces report only the commission they receive from the seller as revenue.

To put this into perspective, it is helpful to compare online retailer to a traditional retailer. A normal traditional retailer would purchase a good, put it on its shelves (inventory) and sell it for a higher price at a later point in time. Hence, the ultimate sales price to the consumer would be recognized as revenue, while the cost at which the good was purchased initially would be recognized as Costs of Good Sold. Online retailers like Amazon (excluding 3rd party sales) have exactly the same business practices like a traditional retailer. On the other hand, marketplaces like eBay or similar platform based business model only act as a platform between seller and buyer and never own the product themselves. In this case, the revenue recognized is only the commission received by the platform from the seller for intermediating the transaction.

The criteria required in order to report gross revenue as defined by the Emerging Issues Task Force (EITF), an organization formed by the Financial Accounting Standards Board to help with emerging financial reporting issues in a timely manner, are as follows [33]:

- The shop is the primary obligor in the arrangement;
- The shop has general inventory risk;
- The shop has the ability to determine the price as which it sells the product;
- The shop changes the product or performs part of the service;
- The shop has discretion in supplier selection;
- The shop has physical loss inventory risk;
- The shop has credit risk.

While the criteria required in order to report net revenues are the following ones [33]:

- The ultimate supplier is the primary obligor in the arrangement;
- The amount the marketplace owner earns per transaction is fixed (absolute or percentagewise);
- The ultimate supplier has credit risk.

These clearly defined criteria, together with a few highly publicized cases of platforms reporting gross revenues, helped the eCommerce industry have a more uniform way of reporting financials. One of the most well-known companies that had to change its revenue accounting method was Groupon. Groupon is in the daily deal business of selling discounted experiences and goods offered by local businesses (e.g. shops, restaurants). In 2011, as the company was preparing to go public, it had to restate its financials, to report net revenues instead of gross revenues causing it to more than halve its reported revenues [9].

While segmenting companies into online retailers with inventory risk and online retailer without inventory risk, one needs to keep in mind that several eCommerce players have developed and are developing their own marketplaces (e.g. Amazon, who also sells 3rd party products), classical marketplaces like Groupon take more and more inventory risk as they can achieve higher margins with sometimes "direct revenue" accounting for 50% of sales [17, 18], and new hybrid type business such as shopping clubs have been developed. Sometimes, even traditional retailers such as Staples which have a well-developed online distribution strategy are entering the marketplace segment [43].

3. The segmentation approach for the companies included in the study

This sub-chapter will take the companies identified previous in chapter 1 and the eCommerce business models identified and analyzed in chapter 2 and try to identify similar companies and to segment these in such a manner that their valuation basis and drivers can be analyzed and conclusions be drown in regards to the entire sub-industry. This chapter will also try to identify and eliminate eCommerce companies that do not fit in these sub-industries and are part of conglomerates of eCommerce companies without a clear revenue split between revenue with inventory risk and revenue without inventory risk.

Appendix 2 shows the segmentation of all companies identified previous in chapter 1. Based on their business model, all companies have been classified as eCommerce with inventory risk or eCommerce without inventory risk. Three companies (Qliro, Rocket Internet and Start Today) have been identified as unfit for the analysis as their reporting is not transparent enough to allow segmentation.

III. CONCLUSION

The article has presented a deep analysis of the eCommerce industry based on public information from different databases and from companies' web pages. This has conducted to fully understand the size and importance of the eCommerce industry, and it has support the comparison with the overall size of the total retail industry as well as the overview of the digital buyers' number that are purchasing online.

Despite being a relatively young sector, the eCommerce sector has reached a certain maturity stage, with valuations in segment increasingly based on expected operating profitability. Furthermore, with the development of the sector, the valuation drivers (key operating performance indicators) shift from revenue growth to gross profitability or operating profitability

Overall the presented study has underlined that, the growing importance of the eCommerce industry is undisputed, however, the decreasing growth rates give away the fact that the industry is approaching a certain level of maturity. As industries mature, the valuation basis and drivers of companies in this industry are also

expected to shift. Generally, as an industry matures, profitability is becoming increasingly important for investors and hence the valuation basis and drivers also go in this direction.

In addition, the research pointed out that the most important part of a valuation base and drivers analysis is to identify relevant companies and by a detailed understanding of their business model, in order to recognize which companies can be compared to each other. Companies need to operate in the same industry, face similar trends and market environment, as well as use similar account standards and practices.

The goal of the presented study was to cover all publicly listed companies in the goods based eCommerce industry, independently of the particular business model of the individual companies and their dominant geography. Consequently, traditional generalist players as well as focused players and players generating commission as opposed to revenues were considered in the research. The further segmentation and comparison of the companies into inventory based companies and platform based companies was presented in a later stage. The goal of this research section was to identify all relevant eCommerce players independently of business model or data availability and relevance.

While there were analyzed various classifications of eCommerce business models, it has been observed that a separation made consistently is the one between classical B2C business model and marketplaces / platforms. When applying this idea to the companies on which this study was focusing – online retailing businesses – it was very clear that the very top level segmentation needs to be between companies that assume inventory risk and companies that do not assume inventory risk.

In conclusion, the research findings are especially important to the numerous entrepreneurs in the eCommerce sector that are looking to sell their companies and which could face the challenge of having to implement a major strategic shift before starting a sales process and implicitly selling the company at a high business valuation.

Future researches will analyses (through simple and multivariate regression analysis) the current revenue and operating profitability based valuation levels of some companies in the global eCommerce sector against several key operating performance indicators.

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APPENDIX 1 - Overview of all companies considered for the study

Company	***Year***	***Country***	***Company description***
1-800-FLOWERS.COM	1976	United States	1-800-FLOWERS.COM is an online florist and gift shop. The company operates in three segments: consumer floral, gourmet food and gift baskets and BloomNet Wire Service. It operates through various brands and online shops.
Alibaba	1999	China	Alibaba was one of the first business-to-business platform in China aiming to connect Chinese manufacturers with buyers abroad. Over time, the company developed additional consumer-to-consumer and business-to-consumer branches as well as cloud services and a payment service. Marketplaces represent the highest portion of Alibaba's revenues.
Amazon.com	1994	United States	Amazon, despite firstly focusing on books, it was one of the first generalist online retailers. Following retail, Amazon expanded into several new areas including cloud services, 3rd party seller services allowing 3rd parties to sell on the Amazon platform, selling and renting of digital good and AmazonPrime subscription services (free shipping, video, music etc.).
AO World	2000	United Kingdom	AO World is a specialized retailer of major household appliances such as fridges and washing machines. It operates under the segments: online retailing UK and online retailing Europe (excluding UK).
ASOS	2000	United Kingdom	ASOS.com is a specialized online fashion and beauty retailer. It offers branded and own label products.
Banzai	2007	Italy	Banzai is a specialized online retailer of technology products and digital content publisher. The company has two business segments: eCommerce and vertical content. The eCommerce segment sells domestic appliances, clothing products, accessories, and household products while the vertical content segment publishes websites, web magazines, advertisements, and applications.
Blue Nile	1999	United States	Blue Nile is specialized online retailer of diamonds and fine jewelry. It also offers in depth educational materials and various tools. The core business segment if the engagement category.
boohoo.com	2006	United Kingdom	boohoo.com is a specialized online retailer of clothing. The company designs, sources, markets and sells own brand clothing, shoes and accessories. It targets 16-24 year old consumers globally.
Cnova	2014	Nether-lands	Cnova is a specialized online retailer focusing on electronics. Insiders own over 90% of the shares and consequently have control. The company operates through two segments: Cdiscount and Cnova Brazil. Cdiscount sales of consumer products mainly through Cdiscount.com while Cnova Brazil sells consumer goods through various shops in Brazil.
Cogobuy Group	2000	China	Cogobuy is a specialized online retailer and marketplace focusing on the electronics manufacturing industry in China.
Delticom	1999	Germany	Delticom is a specialized online retailer of tires, car parts and car related accessories. It has two segments including eCommerce and wholesale. It sells a wide range of tires other related products for car, truck and other vehicles. It also has a few ultra-specialized shops such as a motorcycle focused shop.
eBay	1995	United States	eBay was the first consumer-to-consumer, action style online platform. With time, the company also developed its business-to-consumer segment and added additional features such as "*Buy It Now*" functionality. Furthermore, the company invested fairly successful in various other marketplaces and online classifieds platform.
E-Commerce China Dangdang	1999	China	E-Commerce China Dangdang a relatively generalist online retailer present primarily in China. The company's main distribution channel is dangdang.com which sells books, audio-visual products and consumer electronics among other media products and general merchandise.
Etsy	2005	United States	Etsy is a consumer-to-consumer specialized eCommerce platform focused on handmade, vintage and unique items.

Groupon	2008	United States	Groupon is a local commerce marketplace that connects merchants to consumers by offering goods and services at a discount. The company is present in North America, EMEA and the Rest of World. It operates its business under three categories: Local Deals, Groupon Goods and Groupon Getaways. The company is increasingly also expanding into sale of goods.
JD.com	1998	China	JD.com is a relatively generalist online retailer focusing on electronics and general merchandise. The company's main distribution geography is China.
Jumei	2010	China	Jumei is a specialized online retailer focusing on beauty products. Its product offerings include cosmetics, skin care, make-up and body care.
LightInThe Box	2008	China	LightInTheBox is a relatively generalist online retailer. Its products include apparels, electronics, home and garden products, accessories and gadgets.
Mercado Libre	1999	Argentina	MercadoLibre is mainly a consumer-to-consumer, action style online platform in South America. The company also offers business-to-consumer type services. It provides users a mechanism for buying, selling and paying as well as collecting e-commerce transactions.
MySale	2007	Australia	MySale Group is a members only and flash sales focused eCommerce platform. It sells products of well-known and emerging brands offered for sale to its members for a limited-time period and typically at a significant discount to the brand recommended retail price.
Ocado	2000	United Kingdom	Ocado is a specialized online grocery supermarket. It also offers the Ocado Smart Platform providing grocery end-to-end electronic commerce and fulfilment services.
Oponeo.pl	1999	Poland	Oponeo.pl is a specialized retailer of tires, rims, and other automotive products. It offers tires for cars, trucks, and utility vehicles, steel and alloy rims among other products.
Overstock .com	1997	United States	Overstock.com relatively generalist closeout merchandise focused online retailer. It offers a broad range of products including furniture, housewares, jewelry apparel and accessories, electronics and sporting goods. The company operates through two segments: direct business and partner business.
PetMed Express	1996	United States	PetMed Express a specialized online retailer providing prescription and non-prescription pet medications, health products and supplies for pets. Main distribution channel includes online, national television and direct mail/print advertising.
Qliro	1936	Sweden	Qliro is a group of eCommerce businesses in Northern Europe. It operates through the following segments: CDON, Nelly, Gymgrossisten, Tretti, Lekmer and Qliro Payment Solution. CDON is conducted through the CDON.com shop and also includes a marketplace. Nelly, Gymgrossisten, Tretti, Lekmer are conducted through own web and physical shops while the Qliro Payment Solution is a service offering customers to pay by invoice or instalment.
Rakuten	1997	Japan	Rakuten is a business-to-business-to-consumer platform. It operates 3 segments: Internet Services, Internet Finance, and Others. The Internet Services segment deals with advertising and content sales in Internet shopping malls and various e-commerce sites. The Internet Finance segment handles banking, credit card services and electronic money businesses.
Rocket Internet	2007	Germany	Rocket Internet is a holding company, which engages identifying and building Internet business models. It operates through the following sectors: Electronic Commerce (eCommerce), Marketplaces, Financial Technology, and Travel. Some of the largest eCommerce companies held by Rocket include eCommerce players such as HelloFresh and home24.
SRP	2010	France	SRP Group is French shopping clung focusing on fashion items and beauty products. It sells products of well-known and emerging brands offered for sale to its members for a limited-time period and typically at a significant discount to the brand recommended retail price.
Start Today	1998	Japan	Start Today is a relatively specialized online retailer focusing on fashion. In addition to its own shops, mainly ZOZOTOWN, Start Today also offers a platform in which 3rd party sellers can sell their products on ZOZOTOWN.
Trade Me	2011	New Zealand	Trade Me is mainly a consumer-to-consumer, action style online platform in New Zealand. It operates online marketplaces, classifieds, travel, accommodation and online dating sites. The company has three segments: General items, Classifieds, and Other. The General Items segment focuses on online marketplaces for goods and services.
U.S. Auto Parts Network	1995	United States	U.S. Auto Parts Network is a specialized online retailer focusing on aftermarket parts and repair information. The company operates through two segments: USAutoParts and AutoMD. The USAutoParts segment runs the web shop while AutoMD engages help users identify and compare car repair shops. Products sold include body parts, engine parts, performance parts and accessories.

Vipshops	2008	China	VipShop is a Chinese flash sales eCommerce platform similar to the Western shopping clubs. It offers fashion products, apparel, sportswear, cosmetic goods, home and lifestyle products, luxury goods among others.
Wayfair	2002	United States	Wayfair is specialized online retailer of home furnishing. It offers a home furnishings and decor across all styles and price points through 5 different brands.
windeln.de	2010	Germany	windeln.de is a specialized online retailer of baby and children's products. It operates through the following segments: German shop, international shops, and shopping clubs. The company generates a large portion of its revenues in Asia.
YOOX Net APorter	2000	Italy	YOOX Net-A-Porter is a specialized online retailer of fashion products. The company has operates through 2 segments: multi-brand and mono-brand. The multi-brand segment includes multi-brand online while the mono-brand segment exclusive design online stores.
Zalando	2008	Germany	Zalando is a specialized online retailer of shoes and fashion apparels. The company's product range includes apparel, shoes and accessories for women, men and children.
zooplus	1999	Germany	zooplus is a specialized online retailer of pet supplies such as foods and accessories. The company also offers free content and information, veterinary and other animal-related advice, and discussion forums and blogs. The company also offers pet food subscriptions.
Sources: FactSet (FactSet Research Systems Inc, 2016), Company websites and financial reporting, and Reuters			

APPENDIX 2 - Segmentation of companies included in the study

Company	***Inv. % COGS***	***Gross Marin***	***Comment***	***Category***
1-800-FLOWERS .COM	10.8%	42.1%	Classical online retailer of flowers	eComm. with inventory risk
Alibaba	0.0%	65.8%	B2B marketplace	eComm. without inventory risk
Amazon.com	14.0%	33.5%	Generalist online retailer	eComm. with inventory risk
AO World	8.6%	19.4%	Specialized online retailer of electronics	eComm. with inventory risk
ASOS	31.1%	49.8%	Specialized online retailer of fashion	eComm. with inventory risk
Banzai	8.2%	8.7%	Specialized online retailer of electronics	eComm. with inventory risk
Blue Nile	10.8%	19.2%	Specialized online retailer of jewelry	eComm. with inventory risk
boohoo.com	21.5%	61.3%	Specialized online retailer of fashion	eComm. with inventory risk
Cnova	12.7%	5.7%	Specialized online retailer of electronics	eComm. with inventory risk
Cogobuy Group	7.9%	7.2%	Over 90% of revenue from classic online retailing of electronics	eComm. with inventory risk
Delticom	14.4%	21.4%	Specialized online retailer of tires and car parts	eComm. with inventory risk
eBay	0.0%	74.8%	C2C marketplace	eComm. without inventory risk
E-Commerce China Dangdang	38.5%	18.7%	Relatively generalist online retailer	eComm. with inventory risk
Etsy	0.0%	71.2%	C2C marketplace	eComm. without inventory risk
Groupon	3.7%	51.6%	Local commerce market-place, however >50% of revenue direct sales	eComm. with inventory risk
JD.com	13.1%	12.6%	Specialized online retailer of electronics	eComm. with inventory risk
Jumei	28.9%	40.2%	Specialized online retailer of beauty products	eComm. with inventory risk
LightInTheBox	4.7%	38.7%	Relatively generalist online retailer	eComm. with inventory risk
MercadoLibre	0.0%	71.6%	C2C marketplace	eComm. without inventory risk
MySale	16.4%	19.6%	Members only shopping club with inventory risk	eComm. with inventory risk
Ocado	4.3%	33.1%	Specialized online retailer of groceries	eComm. with inventory risk
Oponeo.pl	9.6%	16.3%	Specialized online retailer of tires and car parts	eComm. with inventory risk

Overstock.com	2.4%	18.7%	Specialized online retailer of electronics	eComm. with inventory risk
PetMed Express	16.3%	33.3%	Specialized online retailer of pet drugs	eComm. with inventory risk
Qliro	15.3%	14.2%	A group of eCommerce businesses; unclear revenue split between marketplace and direct sales	To be excluded
Rakuten	0.0%	83.1%	A group of eCommerce businesses however 50% of revenues are platform based revenues	eComm. without inventory risk
Rocket Internet	12.3%	-3.2%	A group of eCommerce businesses; unclear revenue split between marketplace and direct sales	To be excluded
SRP	24.8%	42.0%	Members only shopping club with inventory risk	eComm. with inventory risk
Start Today	17.2%	92.4%	A specialized online retailer of fashion; unclear revenue split between marketplace and direct sales	To be excluded
Trade Me	0.0%	81.1%	C2C marketplace	eComm. without inventory risk
U.S. Auto Parts Network	23.3%	28.6%	Specialized online retailer of car parts	eComm. with inventory risk
Vipshops	20.8%	25.2%	Online retailer and shopping club	eComm. with inventory risk
Wayfair	2.0%	25.2%	Specialized online retailer of home furnishing	eComm. with inventory risk
windeln.de	14.2%	23.1%	Specialized online retailer of baby products	eComm. with inventory risk
YOOX Net APorter	66.2%	35.8%	Specialized online retailer of fashion products	eComm. with inventory risk
Zalando	28.2%	43.5%	Specialized online retailer of fashion	eComm. with inventory risk
zooplus	17.8%	23.7%	Specialized online retailer of pet supplies	eComm. with inventory risk

eComm = eCommerce
Inv. % COGS = Inventory as percentage of Cost of Goods Sold
Both, Inventory as percentage of Cost of Goods Sold and Gross Margin are based on the 2014 end-year annualized financials
Source: FactSet, Company Information (website and financials), own research