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MOBILE APPLICATION AS AN INNOVATIVE SUPPLY CHAIN CONCEPT AND THE IMPACT OF SOCIAL CAPITAL

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Abstract
EU textile industry with its inability to compete with mass-produced and less expensive imported items, mono-perspective business processes, no solutions for trustful interorganisational collaboration and hardly integration of end-customer in design and production processes conflict trends of technological developments, the rise of individual customer requirements and the success of innovative, flexible and heterarchical environments.
Offering a web-based product-centric collaboration space for dynamic and flexible information exchange between multiple companies including the end-customer can provide a new dimension of efficiency. For the establishment and effective functioning of such environment referred as virtual factory, intense communication and spontaneous sociability are clearly required and are affected by the connecting element that in modern social sciences – in the context of economic efficiency – is referred to as social capital. With this paper the virtual factory simulation shows the possible development of mobile applications for supply chain management, while promoting and using social capital in a decentralised production process oriented to innovative, custom-made products for the textile industry in Slovenia.
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Key Words: Social Capital, Virtual Factory, Supply Chain, End-User Integration, Order Course Simulation

1. INTRODUCTION

At the implementation level of corporate environments, one can detect that the development of technologies and machines in production lines, a focus on the end-user, changing production processes along with time- and cost-effective solutions for maintaining and managing manufacturing facilities are all key areas involved in the transfer of information and in competitive advantages, as well as a vital indicator (of the successful activation) of social capital. All of these areas are marked by the use, development and implementation of information and communication technology (ICT), positively reflecting on the ICT development path taken for the integration of different links of the production chain, the effective transfer of information and knowledge, the promotion of social capital in the flow of knowledge context, and the creation of competitive advantage. Furthermore, with the efficient influence on making an adequate and prompt managing decision it is possible to improve operation of any system [1].

This paper sees an opportunity for networking, information transfer, the creation of new knowledge and greater efficiency in the production chain in the so-called virtual factory platform. Creating an online space for collaboration and the possibility for the continuous interaction of professionals with specific knowledge and workers in the manufacturing process, buyers with suppliers and repairers with engineers or groups of diagnosticians, regardless of these actors' locations, constitutes a new dimension for achieving efficiency in production processes. Drastic cost reduction and time trails, eco-friendly technology with

fewer emissions, a significant reduction in latency and delays and, in contrast, more accessible documentation and knowledge sharing between all actors in the production process, including the end-user, also mean more opportunities for innovation as reflected in the growth and development of European industry.

An example of such a virtual factory, which is addressed in this article, is designed as part of the ComVantage project. The EU Project ComVantage (Collaborative Manufacturing Network for Competitive Advantage) is funded within the 7th EU framework programme and aims to address the limitations of existing manufacturing ICT infrastructure and create a competitive advantage by integrating and taking advantage of mobile and semantic technology. The virtual factory is established on the basis of Web 2.0 best practices and applications for business processes and runs on various devices, including mobile phones and tablet computers [2].

The designed virtual factory, built as an extension to existing business and engineering software (business models are derived as three use cases, namely automotive plant engineering and commissioning, machine maintenance, and customer-oriented production) enables the exchange of selected business data and data about machines' workflow processes and, by doing so, will increase the efficiency and flexibility of business processes, as well as the end-customer's role among all supply chain stakeholders. With this approach the inter-organisational collaboration space is transforming today's organisation-centric manufacturing approach into a product-centric one, allowing de-centralised access management for ad-hoc collaboration between geographically distributed experts (Fig. 1). The premise of this paper is that the success of designed technological solution also depends on the socio-cultural context of the innovation and development where the key role is played by social capital [3].

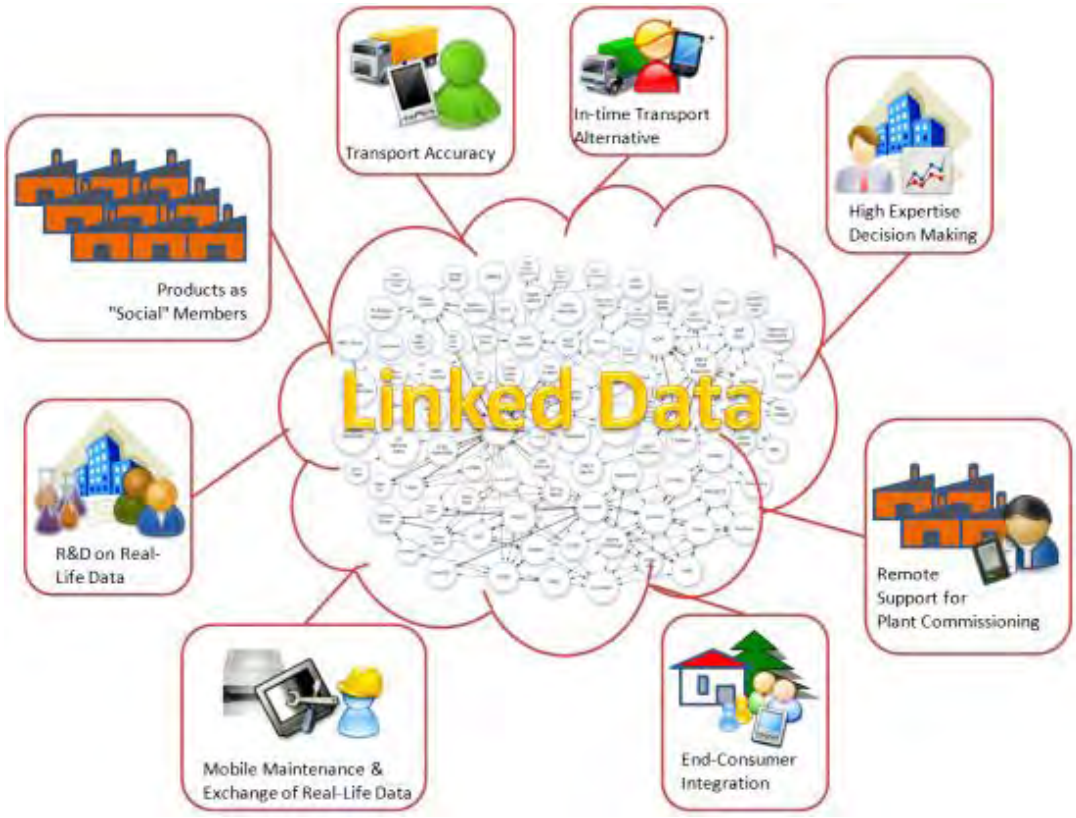

Figure 1: Inter-organisational collaboration via the ComVantage platform.

At the national and European levels, the textile industry has a particularly strong need for new, innovative solutions for its manufacturing processes and new communication channels

for customers desiring an innovative, custom-made product by way of a response to its lack of competitiveness due to cheap labour and the pressure of cheap, mass produced products from Asia. In relation to the textile industry, we envision using a case of customer-oriented production where the aim is to develop a prototype of a virtual factory that enables an active connection between the central stakeholder (a textile shop) and various suppliers on one hand, and the strong integration of the end-customer in the manufacturing process on the other, giving the end-customer the possibility to influence the supply chain and certain product parameters like suppler, delivery time, price, origin etc.

2. SOCIAL CAPITAL AS A BINDER TO SUCCESSFULLY TRANSFER KNOWLEDGE IN THE SELECTED ENVIRONMENT

As mentioned in the introduction, technological development alone is insufficient to successfully establish a network of stakeholders (suppliers, manufacturers, vendors, customers) since the transfer of information and necessary knowledge is also required, which is in turn affected by socio-cultural factors like social capital [4].

We consider the links between the micro-level of individual experiences and activities of daily living and the mezzo-level of institutions, associations and communities. Behind the concept of social capital at the beginning of its conceptualisation there is a series of explanations that connect the micro, mezzo and macro levels of society [5]. We focus on aspects of social capital involved in development (innovation) performance – the issue of designing development coalitions within multifunctional links is shaping social capital as a catalyst for the dissemination of human and intellectual capital as a basis for greater synergy and coordination, as a 'lubricant' of network or project organisations and as a catalyst of intermediary institutions.

In this paper, we are mainly interested in two aspects of social capital:

a) Social capital as a 'lubricant' of network or project organisations

More sophisticated environments are characterised by organisations that are based on projects, are less hierarchical, more flexible and, due to their organisational nature, assume a more challenging form of leadership and communication. Environments in which we perceive a low level of social capital are characterised by the slow development of such organisations. The same applies to the establishment of clusters in different fields, from industry to research teams in universities and institutes.

b) Social capital as a catalyst of intermediary institutions

This aspect relates to the design and association type of organisations, although it also holds broader implications. Social capital is an organisational phenomenon with the ability to create association and project types of organisations. Social capital thereby acts as a catalyst for other forms of capital (human, intellectual) and resources [5].

An environment's most important sources of competitiveness are the innovativeness and sophistication of its products and services [6], while developing competitiveness is largely a localised process associated with localised knowledge and learning. Continuous learning and the creation of new knowledge, particularly in the case of low- and medium-technology activities, is actually the only way such activities can survive in areas where prohibitive costs prevent price competition. In terms of innovation and innovativeness, taking the interactive perception of innovation into account, knowledge is not information but a process, whereby the development and dissemination of knowledge is a social process that assumes inter-organisational learning and communication, which requires a certain degree of interaction. De la Mothe and Paquet [6] point out the assumptions involved in social learning processes. Since they see an innovation as especially representing new practical knowledge, it is essential for an organisation to have the ability to absorb this knowledge which, in turn,

depends on the relations between the actors in the learning process or the form of relations between actors in the innovation system. Here the mentioned authors emphasise the importance of proximity, trust and solidarity values.

Social capital in an environment based on the flow of knowledge and information, entailing flexible, less hierarchical and decentralised environmental management from this point of view, is therefore a key component of the efficiency and effectiveness of the development environment, while it also plays a special role in promoting innovation [7]. In our case, the environment also represents an evolving prototype of a virtual factory whose efficiency is thus influenced by socio-cultural factors, including the social capital of the stakeholders involved.

3. THE TEXTILE INDUSTRY IN SEARCH OF INNOVATIVE SOLUTIONS AND NETWORKING POTENTIAL

3.1 The importance of social capital in the textile industry and virtual factory prototype context

In 2008 another EU project sought to identify socio-cultural barriers to and driving forces of innovation across ten sectors, including the textile one. Researchers in that project agree that social capital is one of the most important determinations of innovation in the textile sector in the EU.

A positive effect is seen in knowledge transfer; nonetheless, the study also underlined that 'negative' social capital within closed structures is hampering people's development due to the old habits of collaborators that hinder individual initiative to innovate. Development opportunity is understood in the setting of the transition from personal relationship-based connections to flexible networking, customers' differentness by fibre, by market and building up of a better and industry-like supply chain, which nevertheless still contain elements of trust (typical of personal relationships) through e.g. peer relations, convincing people, references etc. Due to the typical supply chain fragmentation in the textile industry there is a tendency to consolidate knowledge pertaining to the whole production process. Apart from technological competencies, the textile industry in the EU needs opportunities for interregional and international collaboration, multidisciplinary communication and an open attitude to other cultures, also with regard to labour force mobility and knowledge transfer. To ensure the future development and growth of the textile industry, cooperation with other sectors, certainly including the ICT sector, along with collaboration with the academic sphere is crucial. To establish this, different intermediate structures and connections within companies, sectors and nations are particularly important and especially possible with the development of a virtual cluster like in the ComVantage project example.

An international comparative study of EU countries shows that the vast majority of respondents across textile and other sectors agreed that trust is an important factor determining collaborative innovation activity. The textile industry reveals higher results when we discuss the importance of trust between customers and companies, likewise it seems to be an exception in terms of the level of trust between researchers in the textile industry (with 56 per cent of respondents ranking it as high in the textile sector, and 46 per cent across sectors). The level of trust between companies and in government is low. Respondents in the textile industry recognise shared experiences, informal contacts and collaboration within joined projects, and conferences as the most important factors generating trust. The existence of funding opportunities for collaborative projects is ranked highly as it drives innovation collaboration. The respondents believe the gap between universities and industry is wide and stronger collaboration with research institutes among different sectors is needed [8].

Based on the results of this study, the arguments for establishing a virtual collaboration platform in the textile industry (e.g. a virtual factory) where all supply chain stakeholders can be connected and it is possible to integrate the end-customer into the production process are even more persuasive. They also point to the importance of considering the socio-cultural context (social capital) for the efficient development and implementation of a primary technological prototype.

An important notice regarding supplier involvement in new product development is the issue of what managerial practices affect new product development team effectiveness when suppliers are to be involved. Some findings emphasize the criticality of the supplier selection decision in this type of effort, considering not only the capabilities of the supplier, but also the culture of the supplier, which will have an impact on the buying firm's ability to interact with the supplier effectively [9].

3.2 The textile industry in Slovenia – the status quo of the ComVantage project

According to the European Union, the competitive advantage of the textile and clothes industry in the EU is tied to its quality and design, innovations and technology as well as products with high added value. In addition, cooperation with institutes of technology and universities is crucial.

When it comes to mass production, Slovenian (like other European) companies are too uncompetitive and unable to create higher added value. Current guidelines stress products with high added value, corporate restructuring and employee training, human resources reorganisation and the modernisation of work. Slovenian companies use the largest share of the added value – 84.3 % – simply to cover the cost of labour, with the biggest share being spent by manufacturers of wearing apparel (97.3 %); higher added value can sustain higher labour costs, but this means there is little or no option of having funds available for development and new technologies. This view is considered by some in the clothing industry as more acceptable since it is difficult to develop new technologies and automate processes in that industry. In any case, the proportion spent on human resources costs does not sustain the introduction of new innovative products or create products with high added value. Around 2005, we can detect tendencies of Slovenian companies towards competitiveness with their integration into business clusters. Unfortunately, in 2013, for the majority of associations (IRC Institute MSthat was succeeded by what is today called the ERUDIO education centre, Cetex, SLOTIC, October, etc.) we cannot detect any information that confirms their activities, with the exception of two institutions, and the Association for Textiles, Clothing and Leather Processing as an essential part of the Slovenian Chamber of Commerce and Industry.

The textile industry in Europe is mainly made up by small and micro companies, which are in fact important actors in all business fields across Europe with a growing tendency. Small and medium-sized businesses (SMEs) with up to 250 employees cover 7.6 % of the business economy. Micro companies with less than 10 employees cover 92.2 % of the business economy [10]. In the past few years, the European textile sector has faced massive changes in both retail and manufacturing due to saturated markets, the pressure to offer cheap products, and the ever stronger international competition, especially from Asia, and mass production in importing countries, which all constitute dimensions in which SMEs are uncompetitive. However, there are also some winners in the textile industry (H&M, Zara) which have enjoyed considerable sales increases in the last few years, despite the crisis. Those have abandoned the traditional retail model for their own approaches, and are called vertically integrated companies. These vertically integrated companies are successful at two levels: first, they provide transparency and control of the whole supply chain from the design, production through to the retail of products. Second, they reflect a deep understanding of their customers'

wishes and needs. The present development of ICT tends to transform these success factors into the environment of a virtual company consisting of a network of small companies and creating new potential for European manufacturers and retailers.

Currently, there are few or no innovative initiatives targeting the collaboration of in-between traditional micro companies in the textile sector and the exploitation of their synergies. Typically, these companies are weakly integrated with others or even work quite isolated in their business field. Either they do not have the right information about partners with whom they could collaborate or the communication (mostly by e-mail or phone) is inefficient on a larger scale. Further, end-customers' requirements are rarely integrated into the design and production processes while, simultaneously, there is a rise in the number of requests for individualised products.

For most micro companies the success factor to be competitive in the global market is to provide high quality and/or customised products. New Product Development (NPD) service providers have assumed a prominent role in enabling a more widespread use of Open Innovation strategies, thanks to their ability to acquire, recombine and sell specialized knowledge and technologies [11]. However, there is hardly any application of open innovation and crowdsourcing approaches that gather the knowledge and ideas of customers and thereby improve the product and production process [12].

3.3 The need for networking and investments in R&D in the Slovenian textile industry

To verify the usability of further research and ICT development in the chosen context, a special study within the ComVantage project addressed the Slovenian textile industry.

The data used in this research were gathered between 3rd January and 1st March 2013. Approximately 100 different companies in the textile industry were contacted. Companies curious to learn new things and open to new production and sales forms were especially interested in taking part in this research. All in all, we received fully completed questionnaires from 18 respondents, most of which are companies with fewer than 10 employees; however, small and medium-sized companies also participated in the survey. Most respondents have been in business for more than 5 years. That is also the target group of companies that could obtain the biggest contribution in the form of competitive advantage from the development of a virtual company.

Sixty-seven per cent of the surveyed companies define their products as sophisticated and state that several operations or high-tech demands mark their production. In the implementation phase of new products, 72 % of the respondents use different possibilities to search for and select ideas, with just 22 % of the respondents carrying out market testing. Less than half of the companies perform after-sales activities; these activities include complaints, customer satisfaction surveys etc. Sixty-five per cent of the surveyed companies are organised in a way that enables them to produce the entire product, these are followed by companies which only produce the final product and purchase the components elsewhere while, in third place, there are companies whose form of work is to perform services to customers. The respondents mostly cooperate with Slovenian partners, followed by partners from other EU countries; the share of partners outside the EU is insignificant.

The respondents chiefly cooperate in the area of production (performing labour services). It is particularly interesting that cooperation in the area of quality supervision and assurance follows next. The companies also work together in the fields of marketing, and research and development. Regarding the relationship with their partners, the Slovenian companies participating in the survey are suppliers of semi-manufactured products or suppliers of raw materials to the smallest extent. E-mail is used as the most important communication tool, followed by telephone and fax machines. Web applications are used less frequently (in around

3 % of cases) to communicate and similarly most companies do not use any special information and business systems (SAP etc.); however, if such systems are used, they are mostly in-house information systems. When deciding on ICT, the speed of communication with partners is in the foreground, while 41 % of the respondents see access to more information about a partner and their activities as the second most important advantage. According to the respondents, the advantages of ICT also include the possibility to track the production process and to influence how the production process is carried out. Seventy-two per cent of the respondents perceive mobile technologies as an interesting communication tool; if they had a different opinion they mostly stated that a sufficient number of other ways of communicating exists or that mobile technologies are not used due to the nature of their work or the absence of need.

The penultimate set of questions dealt with sales and the customer, the communication with them and their satisfaction. We asked the respondents to select the characteristics of their target group of customers. In most cases, these are customers who want custom-made products and are followed by customers who demand high quality, customers who want innovative products, average customers, customers who want low prices and, last but not least, customers who think tradition is very important. Most respondents sell their products under their own brand name and they sell them in their own shops, followed by distribution; in only a very few cases are products sold via the Internet. The majority of respondents gave a positive answer when asked if they acquire information from the customer, if they communicate with the customer during the ordering process and if they take the customer's wishes, opinions and demands into account when executing the order. More than 90 % of the respondents also measure their customers' satisfaction. The communication with customers is reciprocal and not linked to the use of any special ICT.

The last set of questions addressed the future of the companies taking part in the survey. Eighty-three per cent of the respondents would like to improve the production processes in their company. Most of such improvements relate to the production per se, with marketing and technology following. The respondents would also like to improve the processes in the fields of research and development, commercialisation, quality control and communication and, according to the priorities indicated by the respondents, these are considered as equal. Networking and cooperation between companies (e.g. in the form of business clusters) as well as with research institutions and institutes of technology are not working well. Nonetheless, the respondents think positively of networking. As regards EU and state aid, more than half the respondents had received such aid.

The present study confirms that companies which are oriented to the production of products with high added value, which have restructured themselves and educate their employees, who renew their human resources and modernise work are also those which are more successful. The problem encountered when trying to perform such activities lies in the lack of financial resources for development and new technologies, and unsuccessful networking in this area. The amount of money individual companies spend on labour costs does not allow for the emergence of new innovative products or the creation of products with high added value.

In relation to the customers, one can detect a tendency to establish more active communication and satisfy the personal needs of the customer who is fond of innovative products/special products/products with high added value. However, the greatest gap is probably the lack of the strategic, oriented and controlled integration of a customer into the production process given that, although the communication may be seen as good, it is largely spontaneous, personal and frequently initiated by the customer.

3.4 The ComVantage concept as a solution for the textile market using mobile and semantic technology

When managing a new product development (NPD) problem, a firm needs to consider the cooperation with its strategic partners in a network because surviving independently in the industry is almost impossible. To facilitate buyer-supplier cooperation, suitable knowledge management and product development process management need to be adopted to match the characteristics of the selected NPD mix. The analysis of the NPD strategy selection project including the analysis of knowledge creation modes and product maturity, and then adopt the most appropriate product lifecycle management, such as knowledge management method and product process management according to the characteristics of the selected NPD project, are necessary to achieve innovative, efficient and effective NPD [13].

Given the presented situation facing the textile industry in Slovenia, the development and implementation of tools offered via concepts such as ComVantage is largely welcome. Yet successful implementation is subject to considerations of affordability, technological accessibility and a sufficient number of users on one hand and a sufficient level of social capital on the other.

Based on stakeholder and customer interviews and on mobile technology latest findings regarding organization and workflow [14], we identified two key requirements to be addressed when taking advantage of semantic and mobile technology:

a) **Lightweight and affordable infrastructure for application in technologically unaware environments.** Especially small and micro companies in Slovenia reveal that they lack a sophisticated IT environment. However, to realise the envisioned application scenario as well as to enhance the competitiveness of such companies the end-to-end transparency of processes is required. In addition, joining the virtual factory network should not require high costs.
b) **Flexible and usable solutions supporting an open virtual factory spirit**. To allow a designer or a self-employed sewer to easily join the virtual network regardless of place and time the technical solution has to be very flexible and easy to use.

The vision of our collaboration network for the Customer-Oriented Production use case and textile industry scenario is that designers, producers and end-customers, i.e. different stakeholders all over the world, collaborate and exchange relevant information in order to control a common supply chain without high transaction costs. Further, innovative services will be developed by integrating end-customers' knowledge into the value chain (Fig. 2).

As a result of the project we envision a prototype for mobile devices whose interface allows better collaboration between suppliers and customers, meaning all stakeholders in the supply chain [15]. This is enabled by the Linked Data based ComVantage platform [16], allowing real-time decisions within the network, providing in-time supplier substitutes, and by integrating end-customers into production processes following open innovation concepts. Prototypical realisation for order simulation process runs in two directions – the first part of order simulation is the application for the customer and is therefore oriented to the end-customer, whereas the second part is oriented to production process stakeholders and represents the application for producers [17].

The aim of the customer application simulation part is to allow more (mobile) customer involvement following an open innovation/open design approach; e.g. with customers being able to access style-recommendation services, shirts designed by the crowd (crowdsourcing) and product information via social media platforms as well as in-time changes of shipping modalities (logotype position, size, colour etc. whilst ever a certain part of the production has not yet finished). The in-time integration of user feedback into the production is also made possible.

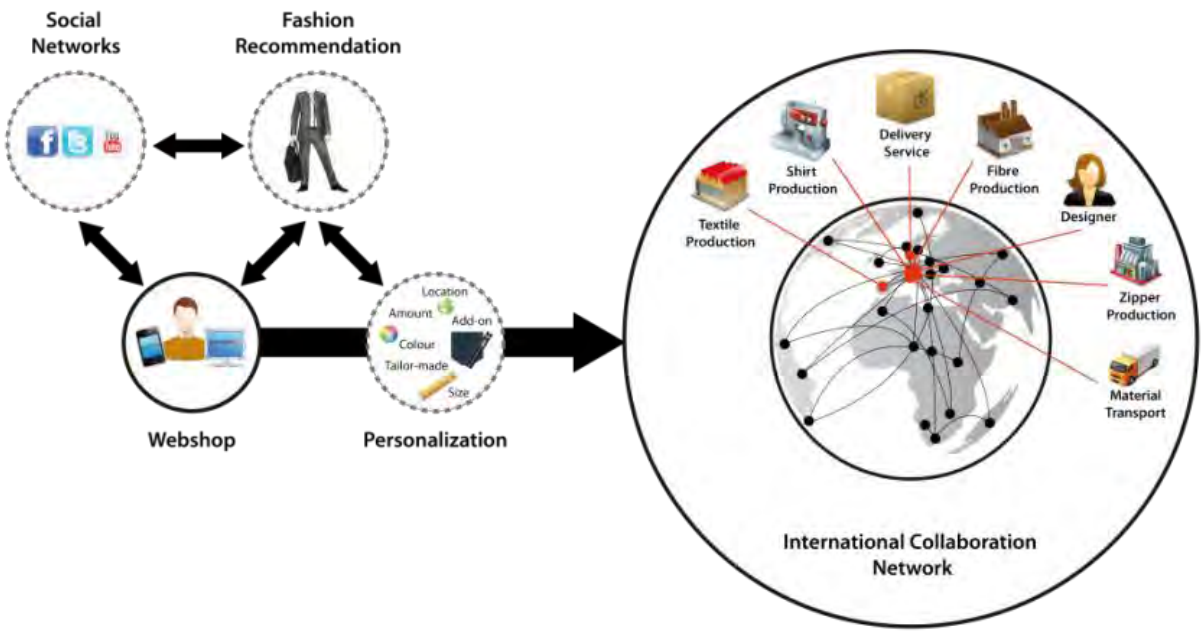

Figure 2: Vision of the collaboration network – an example of the textile industry.

The application gives the customer the possibility to choose product features he considers to be most important e.g. price, suppliers' locations (domestic/foreign material), delivery service, amount, and production time. As soon as the shop confirms an order, the producer application of the order simulation can dispatch the order information to the appropriate stakeholders within the collaboration space (according to a stakeholder's resources, price and location).

Further, the open nature and easily understandable meaning of the Linked Data based infrastructure allows all interested stakeholders (e.g. persons or organisations providing design, sewing, delivery etc.) in the collaboration network to join the value chain by simply downloading the producer application and relevant guidelines. The linking of the different data and systems allows highly personalised, flexible and individually composed production processes. Thus, a small company can become part of a virtual factory and a flexible cooperative network [18-22].

The main benefits of such end-to-end process transparency address the emerging trend of customised products by integrating end-consumer information and that they allow production to occur locally with a small carbon footprint by taking advantage of local stakeholders in the collaboration network (Fig. 3).

Additional investigation in the impact of ComVantage solution – Customer oriented production use case focus on examining the performance impacts of collaboration with both manufacturing partners (upstream) and customers (downstream) enabled by ComVantage platform capabilities. It considers the impact of demand characteristics on the process of value creation, with aim to answer two key questions: (a) How do upstream and downstream collaboration affect operational performance? (b) Do demand characteristics influence this relationship? According to the Simulation Analysis Report, performed by The Ben-Gurion University of the Negev, results show mixed effects of upstream and downstream collaboration on operational performance. While upstream collaboration reduced lead time and increased travel distance, downstream collaboration showed a negative effect on both aspects. These findings demonstrate the inherent trade-off between different performance aspects, which implies that an action should be taken based on managerial priorities of efficiency, cost, and the potential benefits of introducing additional flexibility and innovation. It also points at the importance of combining organisational practices, such as order

transportation management, with the introduction of new Information Technology (IT) capabilities [23].

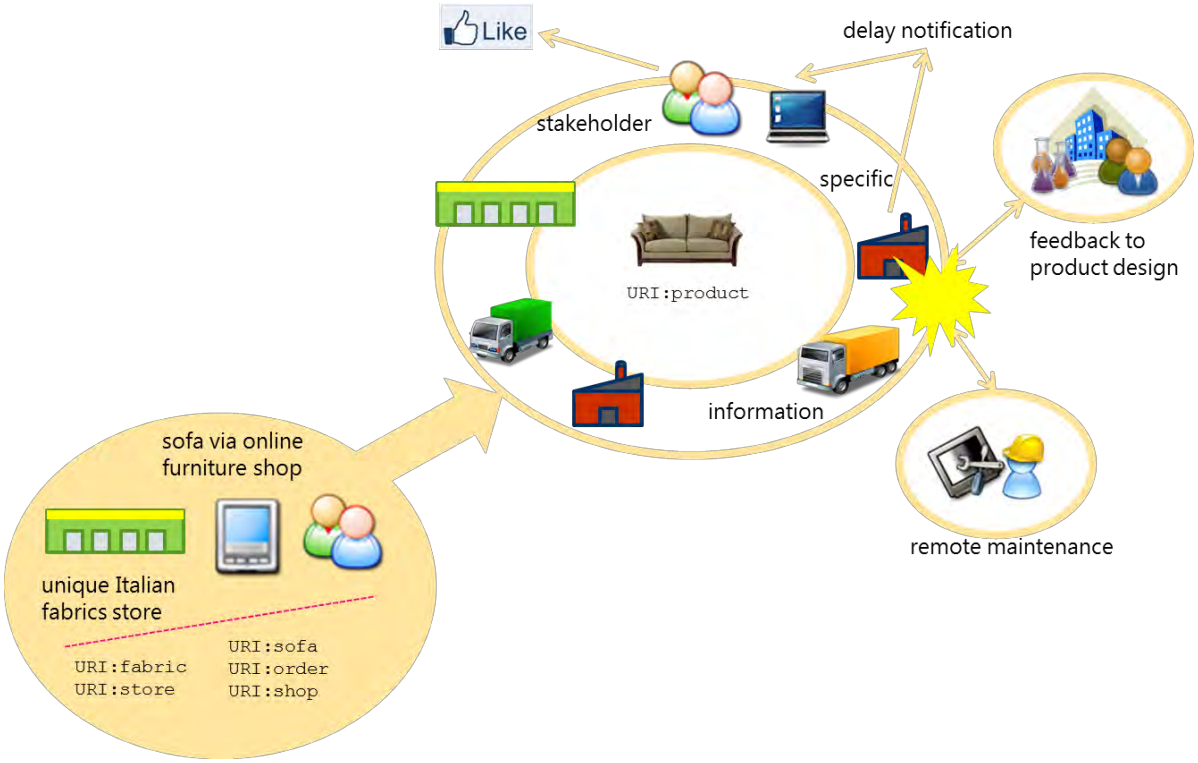

Figure 3: A ComVantage Vision Scenario (an illustrative example of a unique sofa production business process).

4. CONCLUSION

A successful business environment is characterised by flexibility, decentralisation and heteroarchy. Production processes in such an environment may lead to innovative products that directly respond to the personal needs of demanding customers and thus may represent a competitive advantage over the mass production available by way of imports. The establishment and effective functioning of such an environment requires modern, multi-layered and circular information and communication channels which explains why the development of ICT tends to the construction of premises that ensure the easy, safe and fast transfer of knowledge and information between all supply chain stakeholders, including the end-user.

In this paper, the substantive aspect of a concrete example of a prototype of such a place, the so-called virtual factory as a mobile application, that in this specific and useful case builds on and responds to the needs of the textile industry, especially small and medium-sized enterprises. The textile industry is one sector of the economy that has been most affected by cheap imports of mass produced items, and investment in research and development there is significantly below that in other branches [24]. The virtual factory works as a prototype of the ComVantage project that consists of a network of micro-enterprises and creates new potential for European enterprises and vendors. Installations of production lines, customer-oriented co-ordination and modification of production processes, as well as maintenance of machinery are core areas of substantial information exchange for competitive advantage, as shown by relevant literature and research. ComVantage will build on top of best practises from the Web for providing product-centric and workflow-based mobile apps. The collaboration space will

be an extension to existing business and engineering software that enables to share selected business data and machine data of interorganisational relevance. Offering a web-based collaboration space where experts interact with on-site workforces, where customers interact with producing parties, where service technicians interact with construction engineers or diagnostic teams – independent of any location – will provide a new dimension of efficiency. This comprises especially dramatic reduction of travelling time and costs, as well as carbon footprint, essential reduction of latencies and delay, but increased documentation and knowledge exchange throughout all parties including the end-customer, and thus an increased potential for innovations, resulting in a boost for the European industry.

By presenting the benefits of a decentralised production process, the network platform as a virtual factory and simulation orders in the new virtual environment, and by outlining both the advantages and disadvantages for producers and/or buyers, this contribution also highlights an extremely important social aspect of the economic success of this environment – the component of social capital – without which the transfer of knowledge to even the best technological basis is not possible in a way that contributes to the greater presence of innovation and development. It should be noted that the development and successful implementation of ICT for establishing a decentralised, dynamic network environment is influenced by the level of social capital in this environment; moreover, creating the described models in an environment with a sufficient level of social capital also helps strengthen that social capital consequently contributes to greater innovation capacity and development performance.

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