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A NEW BUSINESS MODEL FOR THE ORTHOPAEDIC AND CUSTOMIZED FOOTWEAR SECTOR

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1. Introduction

The orthopaedic footwear sector is typically characterized by hand made production processes, based on the manual work carried out by shoemakers employed inside shoemaking factories or orthopaedic shops. Traditionally, the shoe design and manufacturing processes start from the customer's foot shape, made by the orthopaedic technician through specific foam box or cast and used by the shoemaker to design and manufacture the shoe last, relative accessories (i.e. insole) and, finally, the shoe. The so manufactured customized and orthopaedic shoe is then given to the patient for a trial, to provide his sensations. Finally, the customer bring back the shoes to the orthopaedic technician in order to modify it, if necessary. This kind of manufacturing system is based on poor technologies, that involves a series of issues, such as the related manufacturing costs, delivery times and shoes do not fitting well the customer's needs.

This research work aims to develop and demonstrate a completely new business model for the orthopaedic and customized footwear sector. This model, called *Orthopaedic Footwear Cluster* (*OFC*), represents a completely new concept in this sector. Indeed, the peculiarity of this idea consists in splitting the shoe, and related accessories, design and manufacturing processes, between the hub (big industry) and the nodes (small orthopaedic shops), in order to join the benefits of each subject of the cluster, without losing the customization required by the customers.

The hub is an orthopaedic footwear industry, that supports the nodes with high-value services (research, innovation, design, logistic and manufacturing of semi-finished components) and the node is the unit defined for the treatment of the customer, in terms of diagnosis of his feet, configuration and assembly of the final customized shoe. Inside this concept, the processes related to the footwear design and development are really customer-oriented since they are able to:

- provide a footwear with an high added value, in terms of the important degree of customization, local distribution and therapeutic properties conjugated to fashionable aspects;
- improve the diagnostic, configuration, design and manufacturing systems, and creating, so, the conditions for the reengineering of the traditional overall manufacturing and distribution processes. Key factors are the reduction of the total product lead time and the growth of productivity, necessary to cut the cost of the final footwear.

This paper moves from the state of the art of the business models which could be applied in the footwear sector. Then, the Orthopaedic Footwear Cluster is presented, which represents the new business model objective of this paper. Then, the definition of case study to experiment the business model is presented, although it has not yet been implemented. The paper ends with some conclusions and future works required to optimize the business model.

2. State of the art

2.1 AS-IS situation

The orthopaedic and customized shoes sector is nowadays characterized by two manufacturing situations. The first one is characterized by private or public orthopaedic shops, which have a volume of production ranging between tens up to hundreds of footwear pairs per year, depending on the covered geographical area. This kind of footwear manufacturing, carried out inside the orthopaedic shops, is performed by hand-made processes to create the final shoes, through a series of work-steps made by the same shoemaker; therefore "the production process is strongly characterized by craftsmanship and manual skills" [Franchini 2011]. To perform their work, the shoemakers need many competences on the footwear manufacturing processes that they can reach only after many years of work. For this reason, their competences determine an high labour cost. The final product made following this approach is featured by an high quality, but is characterized by low aesthetic appeal and very high lead times, that can range around 8 weeks. To improve this manufacturing system, huge investments in technology and skills are required but those costs are not justified from the business volume. Indeed the automation of these manual processes requires very expensive manufacturing and designing technologies, necessary to have a production of high quantity of shoes for having an economic return.

Literature presents many studies which allow the actual hand-made processes to be automated. The design phase was the phase of the product development process affected by the most important changes aiming at changing the physical models to virtual ones. Dedicated CAD tools have been developed to model 3D virtual prototypes. The virtual models allow the study of different stylistic solutions in a short time and they automatically provide robust data usable for the following manufacturing processes [Raffaeli 2011]. Understanding footwear design and manufacture is vital for improving the functionality, aesthetics and marketability of a product [Luximon 2013]. The integration of already existing key tools for the design [Davia 2001], [Bernabéu 2013] and manufacturing of custom-made orthopaedic shoes represents one of the most important challenge in the deployment of the presented business model.

The second scenario is characterized by private companies with production volumes ranging between hundreds up to thousands of footwear pairs per year. Even if the scale of the volume is bigger, if compared to the previous scenario, the manufacturing process is the same. In fact, the orthopaedic footwear company takes foot data from the orthopaedic shop and creates a customized shoe by a serial work-steps with the concept "one shoemaker for one shoe". The high cost of expert shoemakers in Western countries, moves this kind of production to Eastern countries, characterized by a less labour cost but also by a poor control on the total quality of the product.

2.2 Requirements to the solution

From such considerations, "new methods of organization and flexible equipments are needed to produce very differentiated products, to obtain reduced work in progress, short response time and low production cost" [Fornasiero 2009].The current production models must be changed because, if considered as separated scenarios, they do not represent the best solution to implement "mass-customization" theory. Since almost twenty years, this term is became very popular for a lot of sectors [Pine 1993], in order to "quick respond to the dynamic customer needs and to face the increasing complexity of products" [Jianxin 2003]. The mass customization paradigm allows the raise of the profitability through a synergy of increasing customer-perceived value and reducing the costs of production and logistics. Soft and hard mass customization theories have been theorized [Boër 2007]. In the first case, the customer interaction point is in sales or retail, whereas, in the second one, the product assembling or manufacturing is in part or completely carried out upon consumer's specifications and requirements. The second theory has a greater impact on the company structure and organization. The mass customization principle is also valid for the footwear sector, as reported by Redaelli [2006] and especially for the orthopaedic customized footwear. Indeed, for this specific sector, the values of the three vectors of shoe mass customization, style/aesthetics, fit/comfort and

function/performance, (Figure 1), assume the greatest possible values within the footwear sector [Boër 2007].

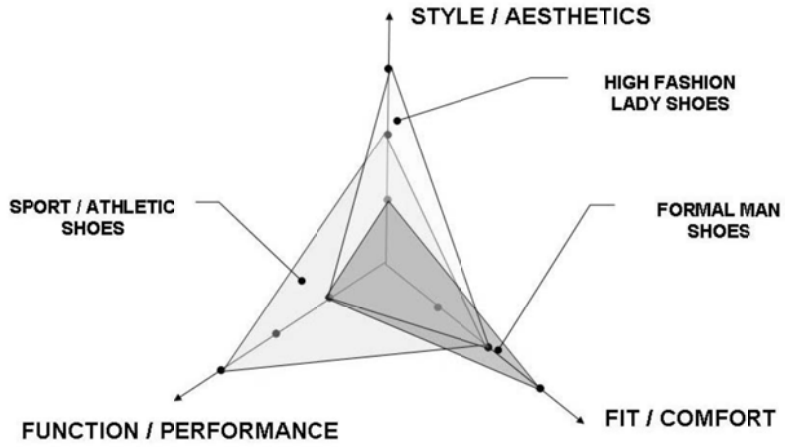

Figure 1. The three vectors of shoe mass customization [Boër 2007]

The mass customization theory can be implemented through the definition of industrial "clusters", where the skills are split between different actors. According to Morosini [2004], the industrial cluster is defined as a "socioeconomic entity characterized by a social community of people and a population of economic agents localized in close proximity in a specific geographic region". Within an industrial cluster, a significant part of both the social community and the economic agents work together in economically linked activities, sharing and nurturing a common stock of product, technology and organizational knowledge in order to generate superior products and services in the marketplace. For those reasons, many small industries must join together for enlarge their market [Libaers 2011]. The solution of the cluster is very useful for the internationalization of the footwear industries and many studies are made on this concept, but they are not applicable on the orthopaedic industry since the products considered are stock shoes.

The orthopaedic customized footwear sector, indeed, it is more complicated than the non-orthopaedic customized footwear one. The degree of customization required is higher, in terms of aesthetic (it is necessary to find the design a shoe that do not highlight the customer pathology), comfort (a curative or preventive shoe has to emphasize the comfort in order to reduce pains) and function (each pathology has to the treated with specific shoes and customizations). An orthopaedic and safety shoe for a diabetic person, for instance, needs to have the same aesthetic of a common shoe, an excellent comfort, in order to avoid the birth of ulcers and the function to safeguard the foot in case of accidents. In this specific context, it is necessary to think a new business model which leverages the already existing business models, addressing the specific needs required for an orthopaedic shoe. The new business model, based on the orthopaedic footwear cluster, has the objectives to pass from a hand-made design and production process, to a more automated manufacturing and to split the manufacturing process of the customized shoes, between industries and orthopaedic shops, in such a way to join the benefits provided by both.

2.3 Business models

During the last years, many new organizational concepts to allow the improvement of the actual design and production systems have been investigated in order to define new business models. Following the definition of Chesbrough and Rosenbloom [2002], a business model can be defined as "a coherent framework that takes technological characteristics and potentials as inputs and converts them through customers and markets into economic outputs. In particular, those studies aim in evolving from rigid, deterministic Supply Chains, to a generation of flexible, open and dynamic networks and clusters". Those concepts are based on the relocation of productive resources and on an optimized management of materials, information and knowledge. The last European Programmes of

research aim to define and develop innovative business models to improve the economical success of the manufacturing companies. The business models innovations has thus become more and more important and lots of research is existing on this topic [Gassmann 2013].
A research project aiming at define a new business model for the footwear sector was DOROTHY [2010]. It was focused on the transformation of shoe industry and related business model to strengthen Europe's ability to compete in terms of high added value for the customer. "This transformation was meant to rely, on one hand, on the development of tools for the design of customer driven adding value shoes and, on the other hand, on the realization of tools for the design, configuration and reconfiguration of flexible multi-site multi-nation production plants" [Pandremenos 2010].
DOROTHY project tried to provide a series of tools to improve the value perception from the point of view of the customer. The DOROTHY project was applied in the stock footwear sector, significantly different from the orthopaedic footwear one, where the style, aesthetics and performance aspects are extremely important. Since this project was related to the stock shoes, the shops are considered as resellers, without any possibility to customize the shoe. For orthopaedic shoes, some components of the footwear must be produced in contact with the patient. In many cases, the final shoes are provided to the patients after a series of adjustments. Hence, it is important that the modifications of the footwear are made in direct contact with the patient, which provides useful information for the technicians in real time.

3. The business model

The orthopaedic footwear production is currently characterized by a hand-made processes, carried out directly by shoemakers inside shoemaking factory or traditional orthopaedic shops. Today, this kind of production is obsolete, in fact, the implemented processes result too rigid to quickly satisfy the customer's needs and also the customization services are limited.
The principal consequences of the current approach are: low product customization and manufacturing effectiveness, low delivery process efficiency (8 weeks are a medium lead time starting from the availability of the foot measurements and footwear requirements) and low patients satisfaction when wearing the shoes, because they are not particular appealing. The direct consequence is represented by the fact that other people could recognize the customer as affected by a pathology since they clearly see him wearing an orthopaedic shoe. For these reasons, the product is not used by patients determining a negative impact on the foot pathology evolution.
To overcome the problems listed above, the current approach to the production of orthopaedic footwear must be redefined. On the base of these needs, the *Orthopaedic Footwear Cluster* has been defined, as described in the following paragraphs.

3.1 Orthopaedic Footwear Cluster

Currently, the orthopaedic customized shoe sector consists of two separated subjects, that are the footwear factories and the orthopaedic shops. The first one seeks to obtain profits exploiting the benefits coming from the application of the mass production principles, while the second one focuses its business on distributing and selling the customized orthopaedic shoes. According to this scenario, the final customer could not find products which satisfy his needs since the orthopaedic shops do not have strong possibilities to customize the footwear. This situation leads to a non-intensive use of the orthopaedic footwear.
The Orthopaedic Footwear Cluster (OFC) concept has been defined to improve as much as possible the product customization with the aim to provide to the end users an high technologic and therapeutic customized footwear and related services with high added value (local distribution, decreased time to market and costs). The OFC tries to achieve those objectives through a new business idea, based on the division of the design and manufacturing processes between the involved subjects, in order to integrate all the advantages provided by them. In this context, the footwear factory and the orthopaedic shops, are no longer separated entities, but they perform a complementary function.
The cluster consists of an hub and several nodes which are in direct contact with the final customers. The hub directly supports the nodes along the entire product development process of a customized shoe, from the patient's feet diagnosis, shoe configuration and design of the related accessories (i.e.

custom made insoles), logistic, production of the accessories and final assembling of the shoe. Within this scenario, the shoe design and manufacturing processes are split in two levels, in order to gain the separate advantages provided by the nodes and hub. The nodes are responsible for a local distribution, making very customized shoes and providing high added values services for the final customers. The hub is responsible of supplying high-added value services for what concerns the shoe design, logistic and manufacturing. They interacts with research centres for the innovation related to the product and manufacturing processes, through their internal laboratories and research departments and they directly interact with the suppliers. The cluster concept has been conceived so that the customers have relationships only with the node while the hub is connected only with the nodes and it does not have direct linkages with the final customers.
The hub is internally structured with advanced design and manufacturing devices in order to provide to the nodes, semi-finished products (standard outsoles and insoles), raw materials to manufacture the high customized footwear accessories, shoes with a low customization level (i.e. shoe without the custom made insole), and the necessary hw/sw tools to design and manufacture the shoe accessories. In this way, the final customization of the shoes occurs inside the node, where the shoe and the re-worked semi-finished products, coming from the hub, are assembled to make a customized orthopaedic shoe which characteristics are very close to the customer needs. This is possible thanks to the direct link between the podiatrist and the patient. This model permits also a reduction of the delivery time since the number of iterations required to finalize the product will be reduced. In the following paragraphs, the hub and nodes are described in more details.
For the proposed idea a business model canvas has been drafted according to the schema defined in Osterwalder [2010], in order to evaluate its economic sustainability and competitiveness.

- *Customer segments*: the customer, currently asks for a customized orthopaedic shoe, characterized by an excellent aesthetics, good comfort and performances, within four weeks from the order;
- *Value proposition*: the OFC has been thought to deliver an high quality orthopaedic shoe to a customer, with the customizations required by his pathology and style. Monitoring services will represent a secondary proposed value;
- *Customer relationships*: the high geographic distribution of the nodes is used to provide an high quality customization service to the patients;
- *Channels*: distribution channels between the hub and the nodes are necessary to exchange materials, physical and virtual prototypes. A web portal is necessary for an optimal communication;
- *Revenue stream*: the economic stream is given by selling the shoe, related accessories and patient monitoring activities carried out directly by the nodes;
- *Key partners*: the key partners are mainly those ones already included within the proposed models (hub and nodes). Additional partners will be required for the logistics, commercial and marketing activities;
- *Key activities*: the activities are split between the hub and the nodes. The hub is delegated to the manufacturing of the semi-finished shoe, research activities, raw material supplying to the nodes, etc., whereas, the nodes are delegated to the final customization of the shoe and related accessories;
- *Key resources*: the resources are related to the innovative technologies supporting the design and manufacturing phases, skilled technicians within the nodes, etc.;
- *Cost structure*: the costs are mainly related to the initial investment to set-up and rump-up of a node, raw materials, employees, and indirect activities as the marketing and commercial ones.

3.1.1 Cluster node

The node is the place where there are the right technological instruments to create a shoe on the basis of specific customer's needs.
Currently, the footwear customization is left to the orthopaedic shops that, in the most of cases, are not equipped with any flexible and innovative manufacturing and managements systems, so, the management and manufacturing is left to the manual and technical skills of the orthopaedic technicians. This situation has a negative impact on the final product in terms of quality, time to

market and cost. The last one, in particular, could be consistent because the orthopaedic shops do not have large production systems, so they can not exploit the advantages typical of the industrial production.
To achieve these results, the current orthopaedic shops should be converted to new entities which own the necessary technologies to obtain the best orthopaedic customized footwear. This transformation, from a classical orthopaedic shop to a centre for the patient diagnosis, footwear design and manufacturing, involves the splitting of the available space in four areas, which are (Figure 2):

- a space for the patient feet diagnosis;
- a computerized and robotized space for the realization of components such as outsole, insole and orthotic devices;
- an assembling space to adapt, modify and finish the shoe;
- a smart warehouse space, managed automatically by centralized information system of the cluster, for containing the semi-finished components coming from the hub.

The first space contains measurement systems, for example 3D scanners, portable instruments for the gait analysis and baropodometric platforms, which are useful for the patient feet characterization. As soon as the orthopaedic technician has got all the patient data, he designs the shoes accessories which need to be fully-customized (i.e. insole) and then produces these components using robotic systems or additive manufacturing technologies, contained within the second area. In parallel, he sends the order for the shoes to the hub. After the internal manufacturing of the shoe accessories and the receipt of the shoe from the hub, assembling operations are carried out to finish the shoe. Finally, the shoe is delivered to the customer for a trial. The patient feedbacks are used by the orthopaedic technician of the node to adapt, modify and finish the shoe. The last area of the node consists of a smart warehouse space where the raw materials and semi-finished products are stored. The node contains only semi-finished shoes received from the hub, which need further customizations to meet the customer needs. The warehouse contains also the final shoes manufactured by the node and ready to be delivered to the customer.
The node would never be able to reach volumes, cost advantages, customization and innovation capabilities of a specialized Hub. In this context, it is possible to increase the product competitiveness (time, cost, innovation and quality) only if the node is coupled with an orthopaedic footwear industry.

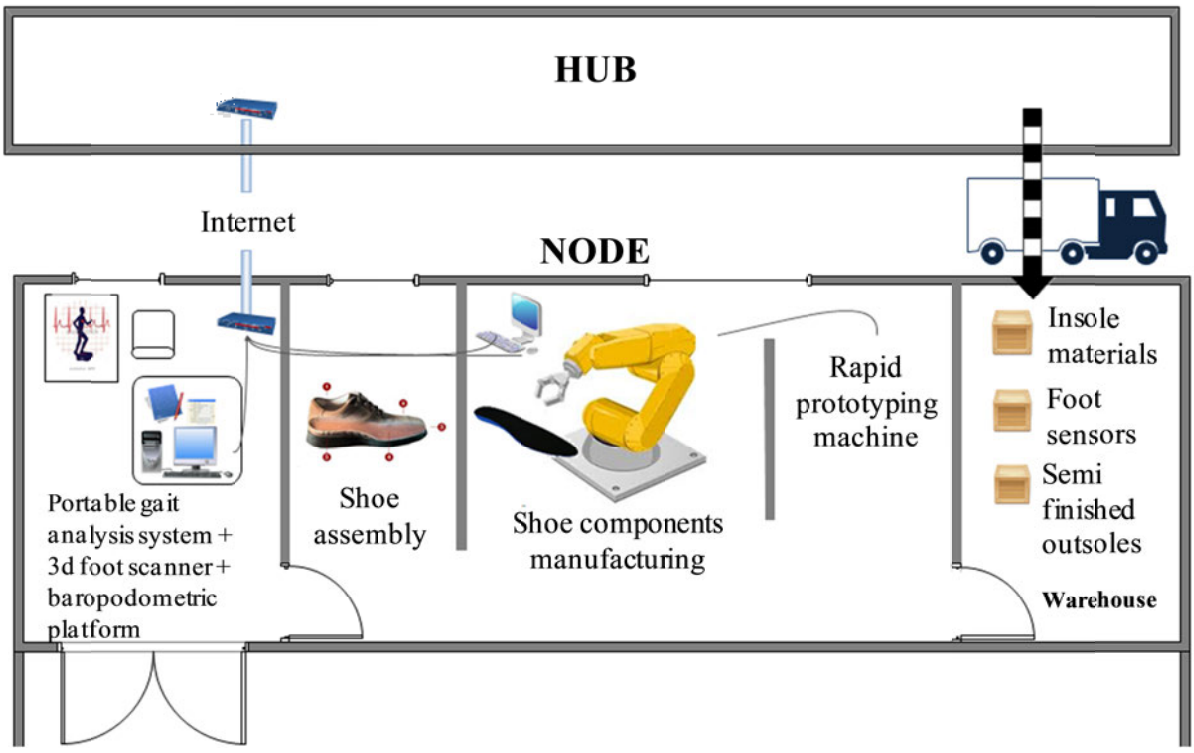

Figure 2. Cluster node

3.1.2 Cluster Hub

The hub consists of an orthopaedic footwear industry characterized by a production rate that ranges around hundred thousand of pair each year, which could be customized or not (stock orthopaedic shoes). This high production scale allows these companies to implement a very efficient manufacturing plant for specific and standard semi-finished components; however, it is not possible to obtain fully-customized products. It worth also to highlight that, sometimes, the manufacturing process of a custom made shoe implies shoe re-working phases of an already existing product (i.e. re-work after a trial test to increase the shoe ball girth). This part of the process could not be efficiently managed within a footwear industry since the manufacturing systems are not flexible enough.

For the above reasons, the hub has to be organized in order to accept from the nodes only an order for orthopaedic and customized shoes but it cannot perform any kind of shoe adjustment or re-working of some components (upper, insole or outsole), so the output consists in a pack of finished components which are sent to the nodes in order to assemble the final shoe with the accessories manufactured by the nodes themselves.

The hub, due to their production dimensions, are structured with specific equipments, laboratories, manufacturing lines which allow them to manufacture high technological and competitiveness shoe and semi-finished components. The hub is in charge also of the activities related to the definition of the shoe style design (materials, colours, shapes, type of lacing, etc.) which requires high skilled employees and very complicated hardware and software systems. The hub dimensions allow them also to fund internal research projects for innovative design and manufacturing systems.

3.1.3 Cluster workflow

The orthopaedic footwear design and manufacturing processes starts when the patient comes within the clinic or orthopaedic shop for a new orthopaedic shoe (Figure 3).

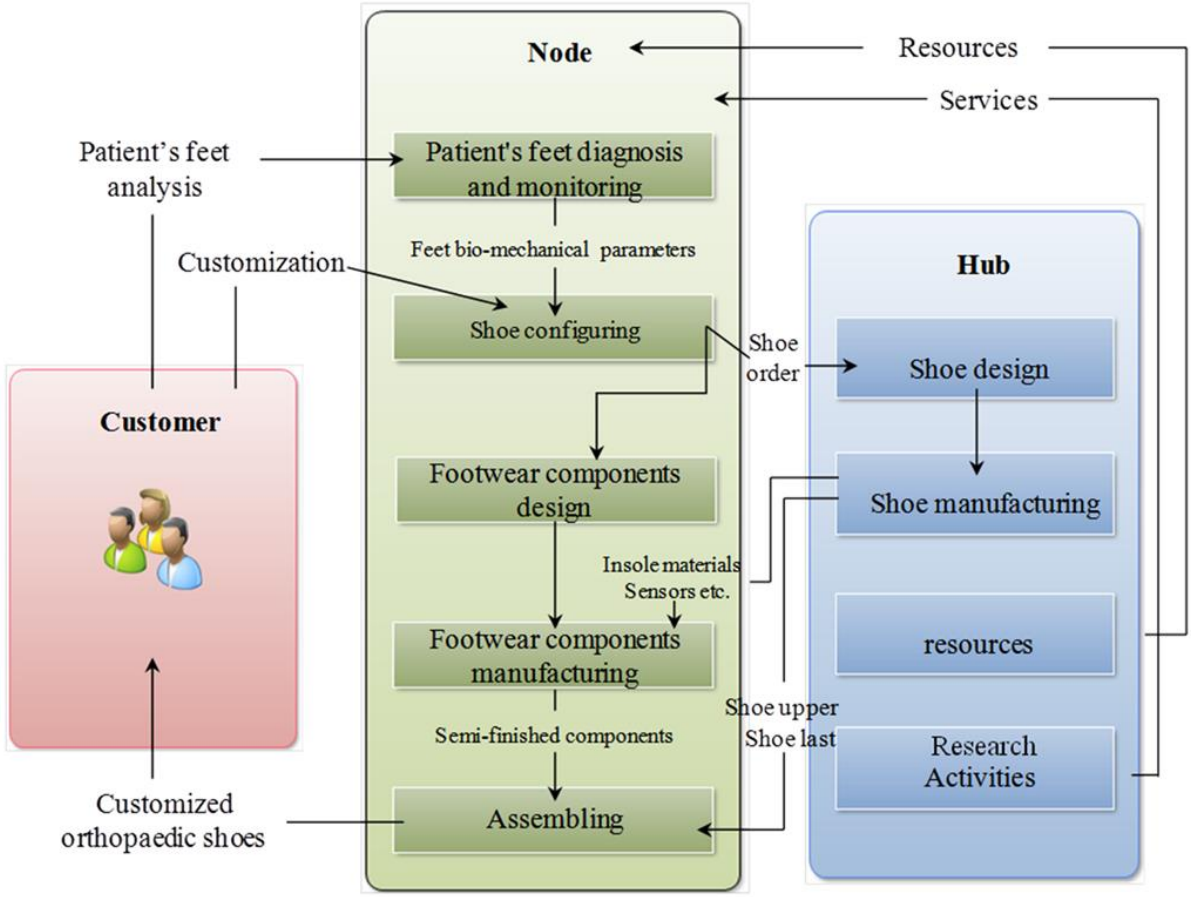

Figure 3. Cluster workflow

The diagnosis and monitoring systems allow the orthopaedic technician to characterize the patient's feet, required for the shoe design. At this stage, the orthopaedic technician, taking also into consideration the life of the patient, he has also the possibility to configure the shoe, and relative accessories (insoles, counters, etc.), through a shoe configurator. The footwear order defined by the technician is then upload within the Cluster Web Portal, then, it is transmitted to the hub. The hub phases are related to the shoe design and manufacturing (shoe upper, last and outsole). According to the outsole types, the manufacturing can be also delegated to the node. The hub output consists in physical (shoe last, shoe upper and shoe outsole) and virtual prototypes (3D shoe last model). The 3D model of the shoe last is used by the orthopaedic technician of the node to design the customized insole. In this process, the node has the possibility to design and manufacture customized insoles, machined using a robotic system, and other shoe components, as counter and orthotics, realized with rapid manufacturing machines. Once all the shoe components are ready, the node proceeds with the assembly phase. At the end, the shoe is given to the patients for the required tests. Eventually shoe modifications will be directly managed by the node using the manufacturing systems it has. The use of knowledge based tools (knowledge elicitation for the diseases to treat is required) supporting the design phase will strongly contribute to the reduction of the number of process iterations.

3.2 Integration of the hardware and software systems to build up the cluster

The improvement of the footwear customization is possible only moving toward more technological management and production systems. For this purpose, the cluster should adopt some kind of technologies, which can be divided in the categories listed below:

- Diagnosis system to scan, measure or analyse the feet;
- CAD/CAM Software tools to support the orthopaedic footwear design and the manufacturing phases;
- Instruments to manage clusters of manufacturing companies;
- Manufacturing technologies.

The diagnosis systems to scan, measure or analyse the feet are required for the design phase of the orthopaedic footwear. For these purposes, the tools used inside the cluster are: 3D scanner, baropodometric platforms and portable gait analysis system. The first one is used to digitize the foot shape inside a virtual environment. The output data is used, for instance, to create the custom-made insole or the shoe last, by the use of specific software systems. Through the baropodometric platform, it is possible to extract a qualitative foot plantar pressure map, and this is very useful for the technicians during the positioning of the insole additions to release the plantar pressure, avoiding, for instance, the birth of ulceration. The last device, the portable gait analysis system, is used to measure biometric data of a moving subject using markers located on the feet. Further diagnosis devices are represented by the in-shoe integrated sensors, that allow to monitor the foot biomechanical parameters, as contact, interaction and comfort.

The footwear design phase is supported by specific CAD/CAM software tools, which are used to create the virtual shapes of the shoe lasts, insole and outsole directly in a virtual environment, without any physical model. The advantages given by the use of these design software tools consist in a reduction of the costs for materials and in a reduction of the product delivery times since parallel operations are now possible (i.e. it is possible to design the shoe upper during the shoe last turning). The CAD/CAM software tools, however, are used in combination with another software tool to manage the cluster, called *Cluster Web Portal* (*CWP*). This system, which refers to the *Supply Chain Management* (SCM) tools, enables inter-organisational management, with a high level of transparency about product assets. With functionalities for communication and co-ordination of distributed manufacturing processes in networks, the CWP enables to plan and to control the product flow and the order fulfilment along the various members of the supply chain.

From the manufacturing point of view, the high degree of product customization could be reached only if specific operations, required to produce the most customized shoe accessories (i.e. insoles) are carried out within the cluster node. For this aim, it is necessary to include within the cluster node innovative production systems, which require small spaces, investments and training. The

manufacturing technologies must be flexible, to manufacture customized products, and intelligent, to support no-skilled workers. The *Rapid Prototyping* (RP) technologies represent a good solution for the above requirements. These technologies allow the production of complex 3D physical parts using multiple materials, such as polymers, metals, and ceramics, the related machines do not require wide workspaces and even their investment costs are becoming quite interesting. Thanks to their capabilities and flexibility, during the last years, the RP technologies have been used in different fields, including the health care sector.

4. Test case and results discussion

The new business model presented in this paper is ready to be tested with partner companies. Here a forecast of the possible benefits for all the members of the value chain is presented. In particular, it is foreseen to involve an hub and two group of nodes. To better demonstrate the feasibility of this model, also in a case of a wide geographic area, the hub and the nodes have been chosen from three different European countries.

The hub is a factory operating in the field of orthopaedic shoes from many years, and his role consists in supporting the cluster nodes, providing them all the stuff (devices, raw materials, technologies, etc.) necessary to create fully customized and technological shoes. The two nodes chosen for this work, are made of an association of independent orthopaedic shoes companies (the first node) and a group of clinics that employ orthopaedic shoemakers, physiotherapists, podiatrists and clinical consultants (the second node). The main role of the end users (the cluster nodes) of the Orthopaedic Footwear Cluster, consists in implement the hardware and software tools defined in this research work.

The very interesting results expected after the deployment of the proposed business model can be resumed in:

- Increased ability to rapidly follow the market dynamics by means of fast production and delivery of customised final products;
- Reduction of the time to market by 43%;
- Cost reduction (around 30%) by decreasing lead times in product and process development;
- Reduced environmental impact per produced unit compared to traditional larger factories;
- Reduction of the set-up and ramp-up time (around 30%) of a new cluster node. These times are respectively related to the activities required to build a node and to adjust the design/manufacturing systems and to train the technicians.

The first result is expected to be achieved by the joint collaboration between the hub and nodes. Indeed, the high distribution of the nodes allows them to be in tight contact with the local population, so recognizing their needs (in terms of aesthetics or pathologies), which are transferred to the hub. On the other side, the hub is structured with research laboratories or with research groups working with universities and research centres, in order to accomplish the even more increasing and complex user's needs. The hub, for example, can study advanced materials to be applied for the insoles production, through specific research projects (even international). The results will be delivered to the cluster nodes for their experimentation, firstly, and use, secondly. One driver to consider for the achievement of this target is the implementation of flexible manufacturing technologies (i.e. rapid manufacturing), to be easily adapted from one kind of operation to another.

For a customized orthopaedic footwear, the time to market is the time from the moment that the patient comes within the orthopaedic shop to configure a new shoe, until the moment when the shoe, already tested, is ready to be finally released to the patient without additional reworks.

The reduction of the time to market pass through the reduction of the hand-made approaches along all the manufacturing process, replacing them with robotic cells and digital measurement tools. For instance, a new robotic cell could be used for the manufacturing of customized insoles, in order to save time if compared with the traditional and manual processes. Besides, the use of digital measurement tools will avoid the realization of a negative cast, replacing the physical transportations (from the node to the cluster) with electronic ones.

Using the new concept of cluster, the shoe customization will be made within the nodes, starting from semi-finished materials provided by the hub. Following this new method, a strong reduction of the shoe reworking steps and wastes are expected. Moreover, the new approach, where both the nodes and

the hub are involved in design and manufacturing phases, allows the execution of parallel operations. For instance, once the virtual model of the shoe last has been designed by the hub, the hub itself proceeds with the last manufacturing phase while the node immediately begins the customized insole design. This behaviour explains the time to market reduction. The reduction of the time to market is attributed in particular to the minimization of the hand made activities. At the same time, the reduction of the number of footwear reworking allows to save an extra time. As an example, a pair of shoes, following the traditional concept, are made with 30 person hours (24 person hours for the creation of the footwear and 6 for reworking, considering 3 reworking). The difference between the 8 weeks said in the state of the art and the hours calculated in this example are mainly due by the logistics within the value chain and the processes synchronization. The new implemented business model allows to create the same shoes by 17 person hours (15 person hours for the creation of the footwear and 2 for reworking, considering only 1 reworking), with a time saving of 43%.
As mentioned before, the concept of the cluster allows also the costs reduction. Indeed, the changeover from a hand-made to a technologic approach, concerning the design and manufacturing processes, determines a cost reduction of the final shoe, even if it is necessary consider initial investments in terms of technology and transfer know-how (i.e. diagnosis, measurements, design and manufacturing systems). Another benefit, coming from the technological approach, consists in the reduction of the shoe reworking steps due by the shoe non-compliance with the customer requirements, as described above. That has a direct influence to the final shoe cost, reducing the human effort and transportation impact.
The environmental impact of a shoe mainly depends on its materials, manufacturing processes and transportation. The cluster's idea, allows the reduction and optimization of the transportations between hub and nodes. This optimization is achieved by the use of internet connection for sending the footwear order to the orthopaedic industry and the only transportation of material goes from the hub to the nodes, for what concerns the raw materials and semi-finished components. The reduction and the optimization of the transportation also allows the costs of the footwear to be reduced.
Finally, the total set-up and ramp-up times, for a new node, must be considered. The set-up time considers the set-up of the new manufacturing machines and foot diagnosis systems and their integration, the warehouse, the training to the employees and the informatics connection with the hub. The ramp-up activity is required to increase the node efficiency and to improve the relationships with the hub. Due to the important use of software applications (the cluster IT management system will manage the network of nodes and hub), it is possible to estimate that a new node could work at full capacity after two month. In fact, the use of technological instruments requires less specialization then the manual process, so the technicians can create the footwear after a short period of practice. The concept of an Orthopaedic Footwear Cluster, as a whole, represents also a unit which can be replicated in different market areas, over the world, also in the emerging markets. This is possible, because all technical instruments are provided by the hub, so the investments of the orthopaedic shops are not high. Also the hub supports the node in all the production phases of the customized shoes.
Considering the general character of the approach, it is possible to extend the application of the methodology to other footwear sectors, such as fashion, which requires less skills and which is characterized by simpler manufacturing technologies.

5. Conclusion

According to the estimation of the benefits described in the paper and determined by the implementation of the Orthopaedic Footwear Cluster, it is possible to conclude that this business model represents a valid solution to surmount the main problems of the current orthopaedic and customized footwear field. This new business model improves the manufacturing processes of the entire cluster, both footwear industry (hub) and orthopaedic shops (nodes). The industry will be characterized by the production of low-customized shoes and semi-finished products in order to exploit all the advantages of the mass production. At the same time, also the orthopaedic shops have advantages, since they can pass from the current hand-made production, to more automated and technological processes. The cluster implementation is also possible with no high investments because all the hardware and software tools have been thought to be flexible, in order to be adapted without

additional costs. By the increase of the automation during the design and manufacturing phases, the customized shoes will be made in less time and cost since this kind of manufacturing requires shoemakers without any particular skills. The lead beneficiary will be the customers/patients because all services about the shoes customization are integrated and, thanks to the large diffusion of the nodes on the territory, the customers can be in direct contact with foot and footwear experts (i.e. podiatrists). In particular, the customer can provide to the shoemaker the real time sensations in order to customize the shoes and relative accessories to his feet and pathology.
The future works will consist in the deployment of the Orthopaedic Footwear Cluster, involving the entities described within the test case section. The aim is to measure the real benefits the proposed approach is be able to guarantee. The principal difficulties to implement the proposed business model are represented by the set of new technologies which need to be implemented within the cluster node. Nowadays, the future cluster nodes, are based on simple and traditional manufacturing processes or, otherwise, are simple orthopaedic shoes reseller. For this reason, the first orthopaedic shops to be included within the cluster will be the first subjects, which dimensions allow them to start with the initial investment foreseen by the model. As soon as the technology maturity of the tools to be used within the node will be achieved, and the costs of investment will further decrease, it is possible to involve, within the cluster, also smaller orthopaedic shops.

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