Techno-economic Analysis of Furniture Innovation: Developing a Green and Smart Furniture for Mass Production

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Abstract. Innovation is considered fundamental for the survival and sustainability of furniture manufacturers in Greece and Europe at least. The paper presents a draft summary of the techno-economic analysis of a non-incremental furniture innovation called GSF as an acronym of green and smart furniture. It regards a smart and purely ecological main entrance furniture piece with incorporated intelligent functions, wood and recyclable materials and eco-based production process. Profit-loss analysis indicates that the new proposal may be successful if it exceeds the Greek market. Initially high costs of specific material and processes may be reconsidered if economies of scale are developed.

Keywords: techno-economic analysis, green and smart furniture, furniture innovation, furniture industry.

1 Introduction

Furniture manufacturing is a highly mature industry based on craft-method production serving primarily local and national markets. However, it constitutes a significant sector in the E.U. with a strong presence globally; European Union is still one of the biggest manufacturers, traders and consumers of wooden products in the world (European Commission, 2013). During the period 2000-2007, furniture industry has known significant growth; a series of global rearrangements of the sectoral players resulted in Asian producers to take the lead and big players to change

the rules of the game. Furthermore, the crisis of 2008 and the continuing severe crisis in Greece intensify the rather negative and risky efforts of Greek furniture manufacturers to survive.

A number of studies (Petrakis et al., 2015; Trigkas et al., 2014, Kumar et al., 2013; Gibson and Naquin, 2013) indicate innovation and differentiation together with the development of extroversion as the only ways for these firms to stay active in the national and global markets. An emerging field for innovation regards the growing concern related to the environmental consequences either in regard of production and transportation or raw materials and the use and disposal of produced goods during their lifecycle (Fankhauser et al., 2013; Costantini and Mazzanti, 2012; Papadopoulos et al., 2010). Furthermore, technological advances and ICT applications offer the potential of novel concepts regarding comfort, usability and even production.

The GSF research project regards the development of a non-incremental innovation based on the combination of ICT and ecological production. Selecting the elderly as the main target group, research focused on the development and market introduction of technologically supported furniture eco-solution to foster the targeted consumers' self-determined living in their homes.

The research was undertaken by the Laboratory of Applied Marketing, Management and Economic of the Wood and Furniture Design and Technology Department of TEI of Thessaly Greece (WFDT from now on). The research team included an ICT company, a furniture small company, two other Universities and a number of external collaborators. The research project has been co-financed by the European Union (European Social Fund - ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program "ARCHIMEDES III Investing in knowledge society through the European Social Fund".

2 Technological Analysis

The innovative furniture product regards an entrance furniture piece called "The heart" (Fig. 1). Its innovativeness lies in the incorporation of intelligent functions while the product is totally ecological. Although there is an increasing trend towards intelligent furniture as well as towards green furniture, it appears that the two trends were never combined. In addition, both trends are relatively new and seem to become stronger as the need of innovation in the sectors becomes more imperative.

The main characteristics of the "heart" are:
   a) Natural wood as core material and more precisely, American oak solid wood of the best quality.
   b) Recyclable supplementary material
   c) The ICT system is composed of an Android tablet, a number of sensors and a PLC. JAVA was used in Eclipse environment using the Android Development Tools (ADT) which extends the IDE Eclipse for Android Projects development.

d) Functions: mirror becomes an information screen (e.g. face recognition, indications about clothing and accessories, reminder of pills or meals etc.)

e) Store room for small objects, documents (e.g. letters, medicine descriptions etc) in interaction with the supplied info by the mirror

f) Specific store room and relevant info on spectacle cases and keys

g) A wheelbarrow with store room attached (as part of the furniture) serving as a sitting or supporting facility or a medium to carry heavy (in terms of the elderly) load.

h) Supporting elements to hang objects (coats, hats, umbrellas etc) with sensors to remind use of them under certain conditions (e.g. an umbrella for the rain).

Design provided the potential to add or remove elements; it can adapt to specific individual needs enabling consumers to choose and buy the parts they needed. Furthermore, the screen can provide info-elements such as news and indications for close relatives and friends added in a friendly and easy way. It has further the basis for co-operation with other smart devices in a smart environment; i.e. inform on security issues.

Fig. 1. The "heart" GSF product

The main wooden parts are the following:
- The basic profile
- The "heart" where the electronic parts are installed
- Store rooms for small objects
- The key ring and folder places
- Hangers (with sensors)

- The supporter (serves as shopping carrier, a seat and a kind of supporter for walking in the house)

The production of the wooden parts follows the normal production line shown in Figure 2. Parameterization of initial panel cutting eliminated waste, try-and-error efforts have eliminated energy needed while water is of minimum use. No measurements have been yet performed regarding CO_2 omissions.
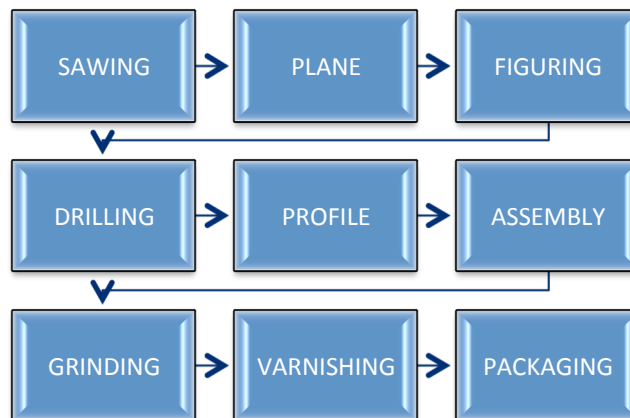

Fig. 2. Production process of wooden parts

The electronic parts have been chosen to be of recyclable material where possible, added to be "invisible" but easy to access in case of technical problem. All supplementary material was recyclable or recycled material. In regard of the ICT part, the system was composed of an Android tablet, a number of sensors and a PLC. JAVA was used in Eclipse environment using the Android Development Tools (ADT) which extends the IDE Eclipse for Android Projects development. Regarding face recognition, the open code OpenCV library was used. Advances in this area will be taken into consideration for improved or new editions of the furniture.

3 Economic analysis

Raw materials are subject to two core limitations; i.e. they have to be totally eco-materials, recycled or recyclable and be able to be assembled by eco-based ways.

Table 1. Cost of raw and supplementary materials per furniture piece

Raw materials	UNIT	Quantity	% loss	€/m³	Cost (€)
Solid wood - oaks	m³	0.02300	19	1,800	41.35
Glulum (Solid Wood Pannel)	m³	0.00244	20	9,500	23.15
Plywood	m³	0.00171	25	700	1.20
Supplementary material					75.25
Electronic Parts					845.7
Total					**986.65**

Therefore, the high cost, especially of the electronic parts, is due to the above specific limitations. On the other hand, elimination of energy consumption and the adaptation of conventional machinery, in order to secure the ecological production, have some impact on the total production costs. Costs are expected to fall in the future due to the development of economies of scale, the advances in the eco-production of electronic parts and automatization and the improvement of the suggested production technologies.

The estimation of marketing expenses in export markets is roughly estimated due to the significant unstable socio-economic environment and the positioning of Greece within the EU framework. Table 2 presents the total cost per piece and the suggested prices in Greece and the European market.

Table 2. Total costs per furniture piece

TYPES OF COSTS *(per piece)* (€)	Greece	export
Raw material	986.7	986.7
Labor cost	176.7	176.7
General Industrial Expenses	140.3	140.3
Packaging/ Distribution / Storage	39.1	78.2
Other costs	26.1	26.1
Total production cost	**1368.9**	**1408.0**
Marketing	261.1	322.00
TOTAL	**1630.0**	**1730.0**
Profit	**244.5**	**173.0**
Suggested prices in Euros including VAT (23%)	**1874.5**	**1903.0**

Prices can be considered high if compared to conventional relevant pieces of furniture. However, they are competitive if compared with high-value furniture (this can be due to design name or ecological value).

Marketing is considered of high importance since it regards the communication of values that combine quality of life to ecologic benefits and support a quite radical innovation. Especially in Greece, such products need to be widely discussed in order to reach a critical mass of consumers and become known. Europe's consumers may

be regarded more sensitive to eco-matters, more prone to information through internet and therefore marketing will not be much more costly than in Greece.

Table 3 presents the profit-loss analysis for the subsequent three years. The time period is considered satisfactory since it regards a radical novelty for the Greek market and it can be assumed among the innovative furniture products in Europe as well. However, estimations are quite moderated, mainly for the Greek market; this is due to the mediocre buying capacity of the third age population at this very moment due to the crisis and the political instability.

Table 3. Profit-loss analysis

SALES VOLUME (IN PIECES)	YEAR 1	YEAR 2	YEAR 3
Sales in Greece	170	190	210
Sales (exports)	400	440	490
SALES TOTAL	**570**	**630**	**700**
SALES (IN EUROS)	YEAR 1	YEAR 2	YEAR 3
Unit price in euros (Greece)	1875	1875	1875
Unit price in euros (Exports)	1903	1903	1903
Sales in Greece	318.750	356.250	393.750
Sales (exports)	760.000	836.000	931.000
SALES TOTAL	**1.078.750**	**1.192.250**	**1.324.750**
Cost of goods sold	812.877,9	898.443,9	998.271,1
GROSS PROFIT	265.872,1	293.806,1	326.479,0
EXPENSES			
Investment expenses (amortizations)	15,315.0	15,315.0	15,315.0
R&D expenses	53,937,5	59,612,5	66,237.5
Other expenses	4,146.2	3,418.0	2,642.4
Taxes	50,043.1	56,019.8	62,993.8
TOTAL EXPENSES	123,441.7	134,365.3	147,188.7
NET PROFIT (before taxes)	142,430.4	159,440.8	179,290.3

The increase in sales volume per year is also the most moderate for the same reasons. On the other hand, the moderate volume of exports is due mainly to two reasons:

    a)   the quite hostile current business environment in Greece that hinders export activity

    b)   the generalized suspicion towards Greek business today, taking into account the usual difficulties of foreign market entrance.

According to net profits per year as they appear in Table 3 and Figure 3, the innovative green and smart furniture has the potential to be profitable even under the most pessimistic expectations. Improvements that have already been planed will improve functionality and user-friendliness enhancing further the value of the new product.
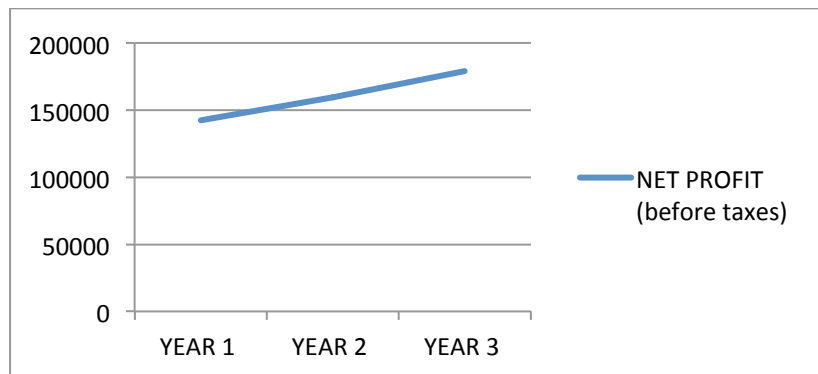

Fig. 3. Net profits (before taxes) in Euros for the first three years

4 Conclusions

The present paper presented the techno-economic analysis of an innovative piece of furniture that combine the ecological value with the information and communication technology novelties. The product is actually a main entrance intelligent furniture piece which addresses every day of the ordinary people and can suit perfectly to the needs of elderly for more self-dependence. However, it may serve other groups of consumers as well.

The development of a techno-economic analysis in the mature and craft-based furniture sector is quite a challenge; markets are quite suspicious against the benefits of intelligent furniture in general since it a just emerging market. On the other hand, ecological perspectives have been overestimated in the past, especially when combined with branded designer names and luxurious shows. Readers should also bear in mind that ICT technology is evolving at very fast paces which may alter the initial costs of the product. On the contrary the eco-production of the wooden and recyclable parts of the product is quite easy to cost. Moving from costs to sales' predictions, difficulties are easy to trace. Besides market analysis, the outline of consumers' attitudes for such products is still quite vague. Furthermore, the severe socio-economic and political crisis in Greece enhances the vulnerable and highly volatile business environment and markets.

Yet, the very moderate profit-loss analysis indicates success under the condition that the product will be simultaneously launched in Greek and European markets. Furthermore, seeing it under a wider perspective, innovation combined to

extroversion is proven to be fundamental for the survival and sustainability of furniture manufacturers in Greece at least.

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