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Innovation and Socio-economic Development of Smart Furnitures by Patent Applications Analysis

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Abstract: Smart Home and Smart City are nowadays frequently used terms which most of the smartphone users and modern urban residents are familiar with. Both these terms cover many of other subterms like Smart Energy, Smart Street, Smart Economy, etc., where one of the most closer for people is furnitures – in a digital world in the form of Smart Furnitures. The goal of this paper is to provide an analysis of innovation and socio-economic development in the area of these Smart Furnitures by the use of patent application analysis and an economic evaluation based on the valuable research in the field. We analyzed 100 patents from Espacenet database, showed the trend in the field including most valuable companies in the area and also the value of patents confirming the investment potential of the field.

Keywords: Smart Furniture, Value, Market, Analysis, Patent Application, Intellectual Property, Innovation, Espacenet**.**

1 Introduction

Smart Devices and Smart Furniture as a component of Smart Home for home applications have attracted significant interests in the past decades. As a typical example, we can name the most actual research for clocks with integrated wireless energy harvesting and sensing functions (Fig. 1) [10] and example of Google Home smart speaker.

Smart Furniture phrase is unfortunately used in various terms, connections and meanings from the design of furniture to be smart, to wall mounted electric socket with an internet connection. Here are some examples of existing definitions:

- Ito, Iwaya, et al. in 2003 [11] defined: „Smart Furniture is a platform for systems to realize Smart Hot-spot. By simply placing the Smart Furniture, we can turn legacy spaces into Smart Hot-spots. Smart Furniture is needed to be equipped with a networked computer, I/O devices, and sensors. Coordination with existing network infrastructure or user's devices is also required.
- Vaida, Gherman, et al. in 2014 [13] provide a definition: "Smart Furniture is the furniture which brings added value, functionality, comfort, and elegance to fit every personalized requirement issued by the user."
- Braun, Majewski et al. in 2016 [2] defined: „Smart Furniture is able to detect the presence, posture or even physiological parameters of its occupants" (Fig. 2).
- According to Technavio's smart furniture market research report [3] "Smart furniture is powered by technological advances such as network connectivity via Bluetooth or Wi-Fi and others, which helps users enhance their furniture beyond its basic analog functions. Smart furniture helps consumers in browsing the Internet for news feeds, weather forecast updates, listen to music. It also offers wireless charging slots for smartphones and has features like distance operation and others".

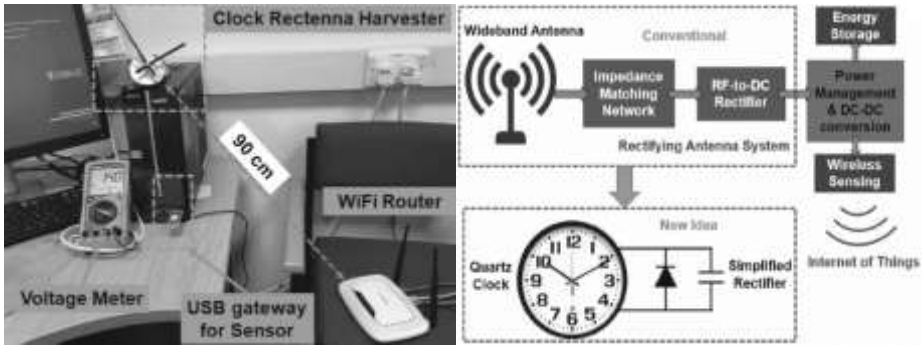

Fig. 1. Left: The real application example of using Smart Furniture - clock antenna to harvest energy from a typical WiFi router at a distance of 0.9 m [10]. Right: The block diagram for energy harvesting quartz clock and their applications in energy storage and wireless sensing [10].

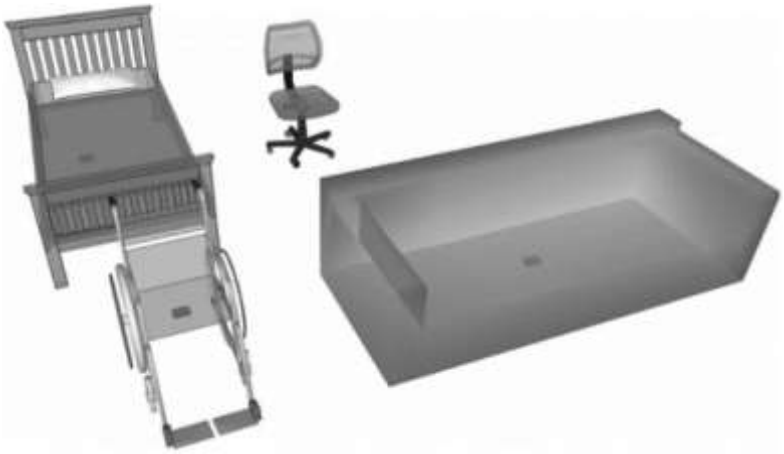

Fig. 2. Potential scenarios for wireless occupancy systems. Bed on the top left, office chair on the top right, wheelchair on the bottom left, and couch on the bottom right [2].

Due to the overlap between industry, technology and people society resulting in the research in basic and also applied research a need to cover a survey of available intellectual property (patents) is needed. To find results close enough to Smart Furniture, this phrase will need to be searched as it is in:

- Topic search (title, abstract and keywords if available) or
- Full-text search (including Claims and Description).

2 Patent Database Analysis - ESPACENET

Patent database ESPACENET provide 189 results based on search phrase Smart Furniture (as topic search) for the last 20 years between years 1998 up to 2017 (based on application date) as there are only 3 records for 2018 yet and older patents are not relevant for our criteria (Fig. 3).

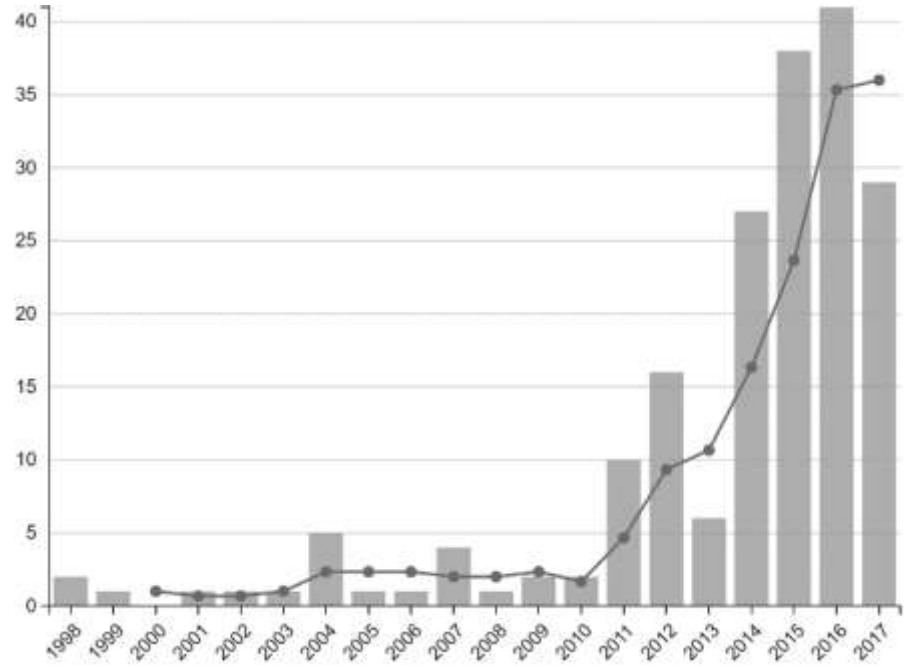

Fig. 3. Distribution of patents in years for Smart Furniture *topic* at ESPACENET database by application date (total of 189).

As there is a possibility to search also a description of patent applications, it is appropriate to cover even this option while searching for results. For the same time frame of 20 years, search result provides an output of 13109 records which is a high number. From these records, 4734 patents were granted.

Unfortunately, these patent applications for given specific search phrase Smart Furniture also cover many records which are not in the connection of Smart Furniture, but in other meaning. For example patent Trust-based resource sharing method and system [15] contain the following sentence in abstract " The present invention is a trust-based resource sharing method and system for managing resources such as accommodations, automobiles, bicycles, equipment, instruments, tools, furniture, and the like during the lease period, using the Internet and smart home technology.". It is possible to limit a search by specific CPS code, or by research area, unfortunately for given phrase smart Furniture it not result to the requested output. Thus we change search phrase from Smart Furniture to exact "Smart Furniture" which provide more precise results. After applying the full-text search, we got 100 results (Fig. 4).

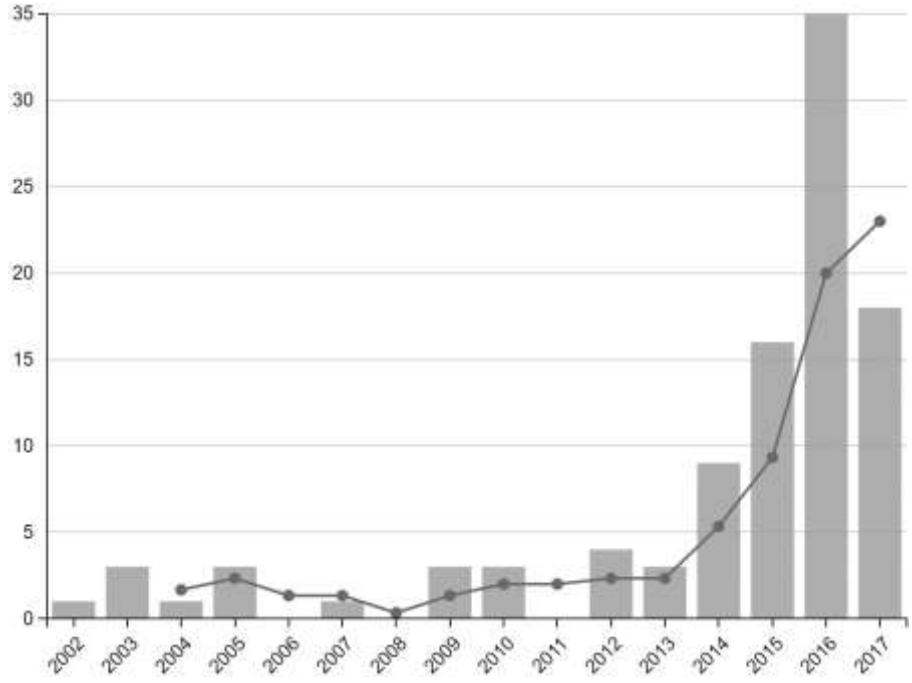

Fig. 4. Distribution of patents in years for "Smart Furniture" phrase anywhere in the application text (full-text search) at ESPACENET database by application date in last 20 years (total of 100).

ESPACENET database provides several searching possibilities. Main is the topic search as it was used already, but instead of primary literature databases (ISI WOK, SCOPUS, etc.) it also offers other searching options which can provide additional results (Claims and Description). These results are summarized with the same searching conditions (years1998-2017 and application date) and exact phrase "Smart Furniture":

- Topic (title, abstract): 33 patents,
- Claims: 11 patents,
- Description: 72 patents,
- Full text: 100 patents,
- Applicants (name of company): 22 patents,
- All: 122.

Previous summarization cover also records for the case when "Smart Furniture" is used as the name of the company. Unfortunately, these records need to be excluded from searching as in this case the patens from these companies have no relation with smart furniture in fact, as they not contain searched exact phrase. Thus the following analysis will be provided for results (100 records) from searching by full text (not including the name of applicants – companies).

Applicant companies cover Amazon Tech Inc. (17), Qualcomm Inc. (9), Samsung electronics co ltd. (3), A9 com Inc. (2), Huawei device co ltd (2), IBM (2), Intel Corp. (2), Nokia Corp. (2), Tata Consultancy services ltd. (2), etc. As the full-text search results for the exact phrase "Smart Furniture" are more precise instead of only Smart Furniture in topics, the trend is, even more, increasing in last three years (2015-2017) what confirming the importance of the area for companies (Fig. 4).

Countries from where applicants are from containing mainly USA, China, Canada, Korea and others (Table 1).

Table 1. Applicant countries at ESPACENET database.

Country (Applicant)	Patents containing "Smart Furniture"	Patents citing "Smart Furniture" patents
United States	38	192
China	18	
World	4	9
EU		7
Canada	6	
Germany		6
Korea, Republic of	4	1
France	2	1
Australia	2	
Great Britain		2
Finland	2	
India	2	
Netherlands	2	
Japan		1
Mexico	1	
Taiwan	1	
Total	100	220

From the all 100 submitted patent applications only 37 is granted, while 63 is not granted yet. Another critical evaluation can be based on citation count for every patent application. These can provide a trend and also investors and companies interest in a given area of research/invent (Fig. 5).

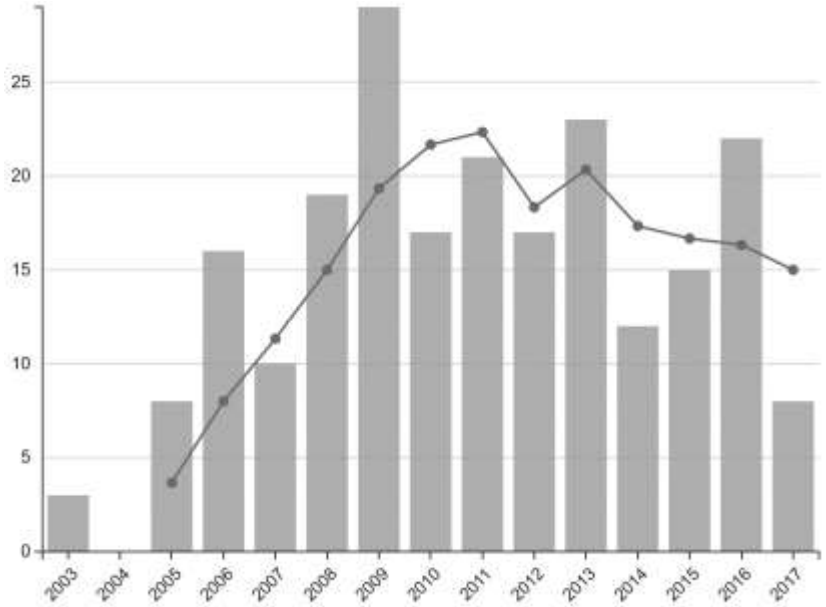

Fig. 5. Distribution of citing patents in years for "Smart Furniture" patent applications searched by full text (100) at ESPACENET database (total of 220).

3 Patents Value Analysis

The patent application represents in most of the cases a result of some invention based on knowledge, research, project, etc. Not every patent application reach the level of granted application as well as not every patent application return the amount of financial investment to applicant/inventor. There are some basic patent application evaluation criteria which can help to recognize the value of the patent. One of the most valuable and easy to recognize is the number of patent citation for a given analyzed application [9,14, 16]. As the researcher use article citation count as a standard article quality evaluation, it can be easily stated that article from Hall, Jaffe, and Trajtenberg from 2005 [5] is the absolute base for prediction of market value based on patent citation analysis because of 1144 citations at SCOPUS database and 1011 citations at ISI WOK. These authors from University of California Berkeley, USA (Hall); Brandeis University, USA (Jaffe); and Tel Aviv University, Israel (Trajtenberg) provide phenomenal results based on research of patents and citations for 1963-1995. They estimated Tobin's q equations on the ratios of R&D to assets stocks, patents to R&D, and citations to patents.

They stated the median value of citations from future patents to 6.33 (based on years 1979-1988) while mean value is 7.95. To understand the context of citation data they put an example of the most highly cited patent since 1976 is patent #4,440,871, assigned to Union Carbide Corporation in 1984. This patent received 349 up to July 2003. This

patent expired on 26th July 2002 while it received a total number of 817 citations up to now (November 2018).

Straightforwardly, they stated, that:

- an increase of one percentage point in the R&D intensity of a firm (i.e., in the ratio R&D/Assets) leads to a similar increase in market value, (i.e., about .8%);
- one additional patent per million dollars investment of R&D boosts the market value of the company by about 2%,
- and an additional citation per patent increase value by over 3%.

The impact of citations per patent is also confirmed by Harhoff et al. from University of Munich and Harvard (1999) (564 citations in SCOPUS) which reported, that a value of the patent is consistent with the "million dollars" worth of a citation [6].

To cover an extensive distribution of citations per patent they break the citation counts to several categories (Table 2).

Table 2. Evaluation of patent value based on citation count separated by the median value of citation (6.33) [5].

Citations/Patent	Value of company	Value of patent/citation [mil. USD]
0-4	Same	1.0
5-6	Same	1.0
7-10	10% more	1.1
11-20	35% more	1.35
>20	54% more	1.54

Hall et al. [5] also confirmed this values on the example of 143 most innovative companies in the market with a median value of more than 20 citations per patent (for the whole patent portfolio of a company). These companies cover names as Intel, Compaq, etc.

For the given example of "Smart Furniture" phrase "RFID smart office chair" patent by Hagale et al. [4] (Fig. 6) is the most cited patent (84 times cited by other patents) from all patents covered by a search in the ESPACENET database (Table 1) where total citations number is 220. Also, this patent falls into the most innovative companies as the inventor is IBM company.

Based on values in the table (Table 2) the price of this patent can be worth of 130 mils. USD (84 x 1.54 mil USD). This patent (by Hagale et al. [4]) was also the first relevant patent in the history containing the phrase "Smart Furniture". Moreover, it contains "Smart Furniture" phrase 4x in Abstract, 40x in Claims and 27x in Description.

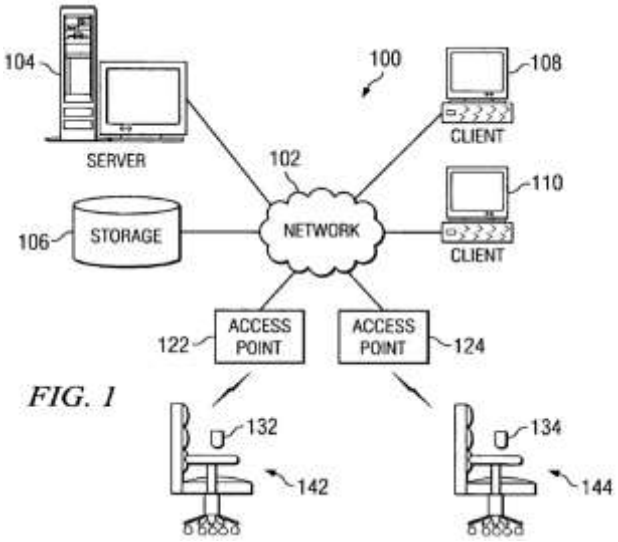

Fig. 6. Schema of Smart Furniture by Hagale et al. from IBM company in August 2004 [4].

Other patents from topic search of “Smart Furniture” unfortunately not have any citation related to “Smart Furniture” in title or abstract excluding only one other “Novel dining table capable of achieving combined and separate use of mahjong machine and dining table” from Chen Jinchen – China (CN203914053 (U), 2014) with one cited patent [7].

For the full-text search of "Smart Furniture", there are several highly cited patents (Irobot corp. (113 citations) [8], IBM (22 citations) [1]) from most innovative companies which confirmed evaluation done by Hall et al. [5].

One of the most current patent application from China with world coverage from the 2018 year[12] deals with a personalized Smart Furniture which can be controlled by a plurality of options based on the information determined by gesture recognition and emotion recognition results. They declared three types of inputs as electrical, audio and video signal which need to be analyzed [15].

4 Conclusions

The goal of this article was to analyze the current state of the art in smart furniture area by a patent database and show possibilities for patent evaluation including economic parameters. Our analysis covered 100 patent applications from Espacenet database as well as 220 citing patents. Using several options for analysis we showed step by step value of selected "Smart Furniture" area, as well as economic potential with determination of value per patent based on citation count, which was based on the most cited literature in the field by Halle et al. [5] containing 1011 citation from ISI WOK database up to now. This evaluation results in the value of the most cited patent from

"Smart Furniture" phrase search represented by 130 million USD. Our evaluation has no ambition to define a unique evaluation method for price determination of patent; thus we are targeting to show a framework with a broader spectrum of evaluation possibilities for the intellectual property represented by granted and valid patent application with citations from other patents. The future direction of our research can be focused on the evaluation of our approach by validation of patent value by the real example of patent or company transfer.

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