ECONONMICS PAPER

NANOBOT

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Economics of Innovations

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INTRODUCTION

Technology has long been an indispensable part of human life. Development of science and technology is now the first priority of many countries and people, since it is one of the most crucial factors that reshape this changing world. In this essay, I will identify and discuss one of the most important innovations that will become the key for evolution of our life in the near future: nanorobots.

1. Identification and description of the Nanobot

Nanobot, or nanorobot, is one of the most renowned applications of the nanotechnology, widely known in the medical field. It's a promising breakthrough that is believed will change future lives: an extremely tiny robot whose components are at or near the scale of a nanometer (Vaughn, 2006; Ghosh & Fischer, 2009; Sierra et al., 2005). In other words, a Nanobot is a million times smaller than the size of an ant and can't be seen in normal condition. Although most inventions are still under the research and development and only a few of them were turned into commercialized innovation, Nanobot' potential is undoubtedly powerful.

First and foremost, the Nanobot is medically expected to contribute greatly in cancer treatment (Saadeh & Vyas, 2014). It can be an alternative for the traditional treatment of cancer-chemotherapy, which is painful and harmful to the patient's health (Venkatesan & Jolad, 2010). Chemotherapy kills not only the malignant cancer cells but also targets other healthy tissues. In some cases, chemotherapy has been proved to bring more harm than good. However, no other equally- effective solutions have been found, and therefore patients have to resort to this only available method. But the Nanobot is expected to fix all of these problems. Due to its minuscule

size, Nanobot can be easily injected to the patient's body. It's designed to detect harmful cells without touching on non-target cells in the body, therefore, help keep the patients from side effects throughout the treatment period.

Furthermore, Nanobot can work as a disease alerts inside our bodies. Some diseases, especially cancer, are terribly dangerous because of their hidden features, which prevents us from acknowledging their existence in our bodies soon enough. As the Nanobot could essentially patrol the bloodstream in search of hostile pathogens, it can diagnosis and detect threatening problems inside our bodies, providing early notifications of future diseases and possibly fix them on the spot.

Another advantage is that it can even diminish any possibilities of a cancer tumor cells remaining, since if only a single cell is left in the body, it has the potential to grow and spread the cancer gradually to the whole body. Surgery is sometimes used to cut out the fatal tumors, but surgeons are just human beings and not likely to work at nano level, which often results in the hidden cancer-carrying cells being left then spread after a successful operation. Also, the Nanobot produces a less invasive treatment than surgery, eliminating many prospective consequences that come with cutting the patient open, such as infection or excess bleeding, as well as decreasing the time and effort necessary for aftercare and recovery.

2. Research and Development (R&D) process

Nanobot is a newfield which was originally the interdisciplinary combination of robotics, nanotechnology and biomedical field. It used to be referred to as the molecular machine, nanomachine or cell repair machine. Nanobot was then developed to serves many practical purposes. In order to match specific application environment, researchers take into consideration actuation methods, design strategies, fabrication techniques, and motion control.

The first scientist who came up with the idea of curing heart disease with micro robots was Richard Feyman in 1959. Molecular machines was first mentioned by Eric Drexeler and it was not until 1998 that Robert Freitas conducted the first study resembling blood cells using Nanobot. However, after that period witnessed the ever-increasing, daily advancing progress in Nanobot research and development field.

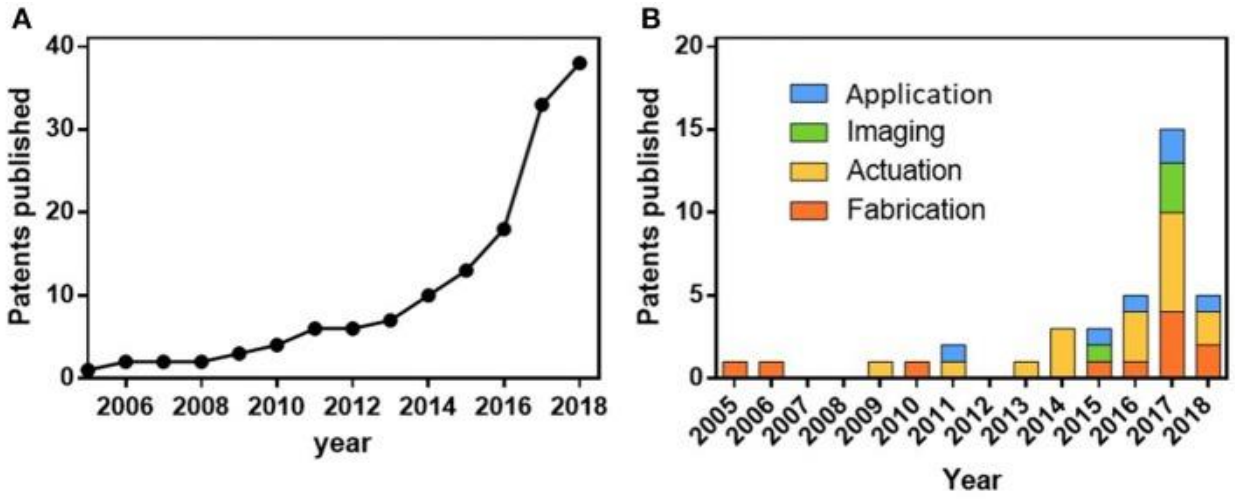
Nowadays, Nanobot is no longer considered an idea but is actually under development. The first patent about the application of Nanobot in medical field was found in 2012 that detects pathogens and toxins inside human body. Another patent was granted in 2016 for Zhang Yi Fei and Yuan Zuo in recognition of a new Nanobot which was produced to “release labelling reagent at the specific point where there is a tumor.” Most recent news in 2018 reported a successful experiment of using Nanobot to attack cancer cells in mice.

Some factors explaining the fast-paced movement of Nanobot development are rising demand in minimally invasive procedures and support from both private and public institutes, the development in nanotechnology which boosts the performance of Nanobot’ components, or even the rocketing demand for cancer-destroying remedies, which is derived from the increasing percentage of human population getting various types of cancer at such a young age.

3. Intellectual Property Issue

The process of turning Nanobot from an invention to an innovation has just happened lately. According to Robert Ferris in 2013, the limited number of patents application and patents grants contributed to the slow growth of this market. Only 3 patents were granted in 2005, 2011, and 2013 respectively that exists the word “nanorobots”.

Nevertheless, considerable progress has been achieved in the field. According to Soto & Chrostowski (2018), nearly 40 patents have been granted lately within less than a decade.



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However, as Nanobot has reached to commercialization stage, the issue of intellectual property will become a big matter of concern in the near future. Nanobot is classified into the biotechnology subject matter, which gains much more attention and benefits after the patents system reforms. As discussed in Gallini (2002) and Boldrin & Levine (2003), the USPTO patents systems are facing many challenges as the application of patents are increasing daily over with the abuse of patents rights.

4. Type of Innovation

There are many different ways to interpret the type of innovation of Nanobot. However, according to definition of pure product and process innovation of Swann, Nanobot can be the combination of both types.

First of all, Nanobot is definitely a product innovation, with intrinsic characteristics. Nanobot is the result of the R&D process, with new features introduced to serve different purposes. This has concurrently created such a "Nanorobot Race", which bears some resemblances to some previous technology races in the history such as nuclear weapons. Big firms in Nanotechnology have paid great attention in working in the development and research of nanorobots, such as General Electric, Hewlett-Packard, Synopsys, Siemens, Northrop Grumman, etc.

In addition, Nanobot can also be categorized as the flexible manufacturing type of innovation. In the long run, Nanobot is a long-lasting materials, light weighted and automatic materials, which can be used as input for further innovations. Medical engineerings and surgeons working towards the wider applications of Nanobot in common medical procedures. Governments around the world also constantly grant funding - which is estimated to be over 2 billions dollars - for researchers at universities and science institutes in the aim of achieving open design technology methods, while bankers are trying to increase investment to gain first-mover advantage and acquire royalties on future commercialisation of Nanobot.

5. Market for technology disruption

Currently, the market for Nanobot is monopolistic with few big firms that own the technology, such as Zymergen Inc, Ginkgo Bioworks, Synthace Limited, Xidex Group, AZoNano according to the report from Market Future Research. As more patents are granted over time, mostly for patents agents and large corporations, in the next few decades, the market of Nanobot is predicted to stay in the monopolistic competition. These firms will invest in the development of Nanobot as the core strategy to continue their patent-claiming era and maintain their positions in the market. The global market is anticipated o touch 100 billions USD by 2023, with its size being expanded 21% compared to 2018.

However, eventually after a long-enough period of time, the technology will be diffused broadly for the general market, as inventors would successfully figure out the less expensive methods to achieve the entry to the market. This market, in the long-term, will behave like the model of a monopolistic competition: the economic profit of an individual firm gradually decreases until it plummets to zero, making the market much less attractive for small and middle-sized (or even large-but-not-enough) firms to enter. Nonetheless, this future scenario is such a long way to go, yet very foreseeable.

6. Restraints for future implementation and further research

While people have hopeful hypotheses about human futures with the help of this technology, many come up with some challenges that act as a hindrance from turning dreams into reality. Movies such as *Blade Runner, 2001: A Space Odyssey,* and shows like *Black Mirror* portray the common social fears of the power of new technologies over economics, social structures, and human reality.

Many critics claim that nanotechnology will result in the unemployment of many people. Nanobot is predicted to be a personalized nano-doctor inside human body to detect any smallest risk. This would lead to the replacement of many healthcare-related jobs, leading to a redundancy of the labor workforce and more severely, imbalance of the welfare ratio of society. However, this will also create a paradox, as a lack of high-skilled workers are expected since the training of personnel to implement Nanobot would take a long time and investment, which consequently raises a higher barriers for entry and thus slower the market growth.

Additionally, this breakthrough in technology and science bring many terrific dangers. Another criticism is that due to the self- assembly feature of the Nanobot, it's possible that it can malfunction and be destructive to the human body if not programmed carefully and correctly, which then ends up in Nanobot population complicating uncontrollably.

Moreover, Nanobot, as other nanotechnology-based application, requires an enormous embodied energy to produce. Every component of such a complex product like Nanobot, will release a great amount of carbon during the production process into the environment. Since the cost of investment in R&D or licensing is expensive, the firms would want to utilize the economies of scale. This would increase the trend of industrial pollution - a negative externality for the society, and also increase the energy volatility price for the firm itself.

7. Conclusion

I believe that the use of Nanobot is worth continuing, regardless of these above-mention hindrances. The life-saving potential of this valuable technology piece outweighs most of the possible risks. The fears brought forward by the introduction of these technologies already exist with the current technology we have; they are merely more exposed. We have entered a new age of science and should take full advantage of its life- saving medical potentials.

The growth in R&D process of Nanobot has achieved considerable advances. Nanobot may possibly improve the growth of medical research and many relevant markets. Every smallest room for improvements in Nanobot can have a profound influence on the lives of many people directly. Hence, it's important to consider the economic, social, and moral implications of the utilization of Nanobot. These implications are probably going to get on par with those of the most critical revolutionary technology upheavals.

In conclusion, nanorobot has the potential to lead to revolutions in the next era of science. It is both greatly beneficial to human beings and plays important roles in transferring and transforming of our daily lives into the fast-paced, modern world. Funding should be directed towards programs that reduce the cost of production and strengthen the efficiency of these technologies so that the right tests can be done, and they can start saving lives.

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