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SHORT COMMUNICATION

Two Dimensions of the Ethical Problems Related to Nanotechnology

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Abstract The current literature on nanoethics focuses on a wide array of topics such as equity, privacy, military, environment, human enhancement, intellectual property, and security. The identification of those topics leads to the adoption of an ethical stance, which we call the *in itself dimension*. In this article we argue that even though it is correct to identify the areas where ethical problems are imperative to deal with (*in itself dimension*), it is a partial approach. This is because the *in itself dimension* pays no attention to another ethical stance; one that does not have anything to do with individual or collective responsibilities, but rather with the socio-economic system into which those responsibilities are embedded. We call this second issue *the contextual dimension*.

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Introduction

The debate on the ethical aspects of nanosciences and nanotechnologies (NT) has resulted in a large number of articles, courses, research networks, congresses and workshops. The current literature on nanoethics focuses on a wide array of topics linked to nanotechnology such as equity, privacy, military, environment, human enhancement, intellectual property, security, and several others. The identification of those topics leads to the adoption of an ethical stance, which we call the *in itself dimension*. In this article we argue that even though it is correct to identify the areas where ethical problems are imperative to deal with (*in itself dimension*), it is a partial, or incomplete approach. This is because the *in itself dimension* pays no attention to another ethical stance; one that does not have anything to do with individual or collective responsibilities, but rather with the socio-economic system into which those responsibilities are embedded. We call this second issue *the contextual dimension*.

The difference between the two is crucial. Moreover, if we only pay attention to the first dimension, the eventual result would be to correct and/or adjust the different responsibilities with nanotechnologies without altering the current socio-economic inequalities, which

is the cause for most social injustice. In contrast, if we acknowledge the existence of a second ethical dimension, one that implies profound changes and in which adjusting responsibilities is not enough, then we will have to think about mechanisms to alter the economic forces that shape and structure those responsibilities.

1. The *in itself* dimension of the ethical problems associated with nanotechnologies

Ethical positions account for the justification of behavior, positive or negative. In general terms, it is acknowledged that there are three explanations associated with the different ethical positions.

One is *natural law*, or pre-established order. For instance, there might be the case in which an environmental movement can argue that "mother nature" is wise or creates equilibrium, and it can also argue that human behavior is *naturally* harmful to the environment. Therefore, evoking a naturalist principle leaves little, if any, space for the debate. One example of this can be extrapolated for the case of nanotechnology. The endorsement of nanotechnology can be associated with the argument that technology development is a good thing in itself and arises substantially from human nature.

The second explanation is related to the *consequentialist* principle. This principle pertains to the idea that the end in itself justifies the means. In other words, if the outcome is positive the means used to achieve the outcome need not to be discussed. When it is argued that nanotechnology must be developed because it can be used to cure cancer, provide cheap drinking water or store solar energy more efficiently and cheaply than today, nanotechnology development is justified as a path of these promising results. But, this is supported without paying attention to other factors such as property rights, impact on labor and/or the environment.

A third explanation is to understand behavior linked to the cloaking of legality (deontological principle). It can be shielded by current legislation or bylaws. For instance, if a soldier kills another soldier in battle, it is not murder. On the other hand, if the killing occurs in peacetime, then it would be a case of murder, even though we are talking about the same action. Therefore, the argument that the risks associated with nanotechnology should be analyzed under current legislation because they are developed from the same materials that were covered by that current legislation, is related to the deontological principle. Despite the fact that scientists are applying nanotechnology to the same raw materials to discover novel properties, they are also encountering new consequences and unknown risks, which entails the creation of new and specific regulations.

In each of the previous cases, the behavior of an institution or a person can be justified simultaneously by more than one principle or explanation. The earlier classification, however, is a useful tool to bring to the ground the abstraction of the principles and to understand individual possibilities.

The modern literature on nanoethics focuses on specific topics, related to responsibilities associated with the use of nanotechnology developments. Under this framework these topics outline reflection and ethical discussion. These topics are: equity, privacy, military, environment, human enhancement, dual use, intellectual property, security, etc. [17, 19–21]. There are others who have created a classification of topics [6, 22]. The identification of the topics that shape ethical positions on nanotechnology is helpful to organize the discourse and analysis of the responsibilities; nevertheless, it does not question the socio-economic forces that give origin to those responsibilities. It is right, however, to argue that the identification of responsibilities and the corrective mechanisms are essential, but this should translate into better living conditions and social justice. If this change for the better is not happening, then we would have to commit ourselves to identifying the causes and thus provide concrete solutions to those problems, beyond classifying and discussing collective or individual responsibilities.

2. The "contextual" dimension of the ethical problems related to nanotechnology

The socio-economic forces that shape responsibilities are subordinated to the functioning of the capitalist system of production. One evident trend within this system is the concentration of wealth. This trend is also reflecting upon nanotechnology despite the few years of its research and development (R&D). Let us observe, for instance, data related to the investment ratio in nanotechnology. Consulting company Cientifica provides the following figures for the first 10 countries (Table 1):

Table 1 Investments in nanotechnology R&D estimated for 2008

Country	Ranking	Investment in US dollars (million) (2008 estimated)	Investment in US dollar (million) corrected by purchasing capacity	Ranking
World		7,849		
EU 25	1	2,440	2,787	1
USA	2	1,821	1,821	4
Japan	3	1,128	995	5
Russia	4	1,076	2,107	2
Germany	5	541	411	7
China	6	510	2,034	3
Korea	7	350	440	6
UK	8	184	141	10
Taiwan	9	97	175	9
India	10	50	213	8

Source: Based on [2]. *The Nanotechnology Opportunity Report*. 3rd Edition. Retrieved February 19, 2009 from: http://cientifica.eu/index.php?option=com_virtuemart&page=shop.product_details&flypage=shop.flypage&product_id=34

The previous Table 1 shows the big ten players in nanotechnology according to the investment allocated for R&D. We can observe that the only developing countries are China and India, both very large GDP nations. The report issued by Cientifica argues that the previous chart does not reflect the role of each country in nanotechnology. Therefore it provides a different chart considering the purchasing power parity. This shows that a researcher in Germany costs more than in the US and one in China or India is significantly cheaper ([2], 37). For this reason, China and India are ranked higher using this methodology; which is a demonstration that only developing countries with large GDPs are able to jump in the wagon.

Another indicator of the concentration of wealth is the monopolization of patents. In [7], the ETC group offered the following highlights on the matter (Table 2):

From the previous Table 2 we can observe that the concentration of patents by large transnational corporations is a fact and a problem by itself. The only exception is the University of California, but still is a US based university in close contact with the business sector. The trend related to the concentration of patents is not expected to change in the years to come. And, this is not exclusive to the nanotechnology sector since this happens in any other sector.

Another indicator of the concentration of wealth is related to the production of nanoparticles and nanostructures, which are raw materials for other industries. The report issued by Cientifica is also punctual in this regard. It clearly shows that after few years of nanoparticle and nanostructure development, large chemical corporations have controlled the market of these nano-manufactures. The explanation is that

Table 2 Concentration of patents according to the classification 977 of the US PTO (as of May 25, 2005)

Company/Institution	Headquarter	# Patents
Canon Kabushiki Kaisha	Japan	49
IBM	USA	47
Silverbrook Research	Australia	28
The United States of America	USA	16
Hitachi, Ltd.	Japan	16
Seagate Technology	USA	16
Micron Technology, Inc.	USA	14
Eastman Kodak Company	USA	13
Olympus Optical Co., Ltd.	Japan	10
University of California	USA	9
Rohm and Haas Company	Germany	9
Polaroid Corporation	USA	9
Sony Corporation	Japan	8
Molecular Imaging Corporation	USA	8

Source: ETC [7]. Nanotech's "second nature" patents: implications for the global south. March/April and May/June-2005. Communiqués No. 87 and 88. Retrieved September 1, 2006, from http://www.etcgroup.org/documents/Com8788SpecialPNanoMar-Jun05ENG.pdf

only the large corporations such as BASF, BAYER or DOWN Chemicals are able to produce both nanoparticles and nanostructures with the required quality and in the demanded quantities.

> 'Five years ago if you wanted nanomaterials you would have to deal with a few guys in a garage, or a professor and some grad students earning a bit of cash on the side. Now, if you want the same material, you can buy it from a number of established chemical industry suppliers. Crucially, the big suppliers have strict quality control procedures. That means if Boeing want to use a new nanoparticle based composite, they can be sure that they can buy the same thing next week, next year and in 10 years time, and that companies like BASF will still be in business next month. This ability to buy large quantities of well-characterised materials is what will bring nanotechnology to market. While my numbers indicate that the growth rate in the nanomaterials industry looks a healthy 20–30% CAGR for the next 5 years, the real explosive growth will be in the applications of those materials' ([2], 28).

Another example that illustrates the concentration of wealth in the nanotechnology sector is what happens in the textile industry. It is known that in the 1990s this industry established most of its production lines in South-East Asia. However, most of the necessary nanocomponents to be applied in textiles are being developed in the USA [2]. This means that if this trend continues the US will control the bulk of the nano-textile industry even though most of the production lines would be based in Asia. Asia will have to buy the necessary nanocomponents from the US, a structuring of the market of nano-textiles which will concentrate power and wealth in this nation.

Other elements are going to play an important role in the deepening of the concentration of the profits from nanotechnologies. The most important is the world economic crisis that started in 2007 for some and for others in 2008. The question is simple; the crisis undervalued the stocks of many companies. Under this circumstance venture capital is not profitable or at least worth entrusting for this purpose. There is little chance for small companies to obtain credit or to attract investment to allow them to enter the market with some possibility of success. An expert from Cientifica recently stated that:

> '…the high risk factors combined with the high ROIs required by the venture capital industry mean that venture backed nanotechnology start ups are thin on the ground' ([13], 2–3).

This effect has implications for inequity and underdevelopment. The concentration of the power of nanotechnology in the hands of few transnational corporations headquartered in developed countries goes hand in hand with inequity. Under this scheme there is no other outcome but the concentration of wealth, even if this means an increase in inequality or in the number of dispossessed (either companies, countries or persons). The problem of inequity, which entails unemployment and poverty, is not the responsibility of a particular entity, neither of an institution nor many other organizations. This is the final outcome of a process that encourages competition in unequal conditions.

3. The two dimensions and their interrelation

In this section we discuss both dimensions of the ethical problems associated with nanotechnology. The concentration of ownership of nanotechnologies by large transnational corporations and the consequent inequity in other sectors and countries is not to be solved by adopting any of the ethical stances explained in the first section or by fostering the *in itself dimension*. It is clear that some problems can be fixed and many other things improved, justifying the existence of ethical positions. But, the second dimension (contextual) requires a different approach, away from specific rules or codes of conduct. Nevertheless, before considering the contextual dimension it is worth to give some thoughts to the use of nanotechnology to help solve the problems of the poor, such as improving water quality, agricultural productivity enhancement, and so on. At first glance, the orientation of nanotechnology research and production towards key development issues combines a pro-poor individual behaviour with an also pro-poor social outcome. Several authors push forward this approach [18, 24], although criticized by others [15]. However, a deepen view will show that society is not the addition of individual behaviours, but of emerging social relations that constrict the possibilities of individuals. First, production depends on previously

distributed and concentrated capital, as illustrated above with the socio-economic trends in nanotechnology. Second, the aim of production under capitalist relations is profit, as any honest businessman will recognize; which subsumes best intentions to market laws. Third, under capitalism, the development of technology drives to an increase in unemployment, as recognized since David Ricardo. Fourth, the precedent trends put the workers and poor people in a fragile position to take benefit of the products of nanotechnology, no matter its virtuosity to address the problems of the poor.

Now we can move back to the socio-economic arena. It is necessary to understand that the socio-economic trends that give rise to the concentration of nanotechnologies, which are the responsibility of no-one, bring about more benefits to certain classes and sectors than others. Enterprises, large corporations and rich countries are the most likely to gain benefits, and thus, would be interested on defending the *in itself dimension*. They are likely to foster and encourage the discussion under this framework, as long as "the rules of the game" do not change. In other words, this means the control of risks as long as they do not imply less profit; the adoption of voluntary codes of conduct rather than mandatory regulations implemented by governments; the guarantee of health and environmental security only after obtaining technological developments to deal with these issues; and all these only after allocating nanotechnologies in the market. If we study some historical facts in terms of proposals to regulate nanotechnologies, we will find interesting features.

First, we can observe that the justification for nanotechnology R&D embedded in most, if not all, National Initiatives is to encourage the country's competitiveness. This has been clear since the creation of the National Nanotechnology Initiative of the United States in 2000. The legitimization of the research by connecting its potential to enhance competitiveness does not guarantee the improvement of the living conditions of the population. At the most, it only offers (to some) the possibility to obtain more profit. This subject is a matter of concern because many developing countries are clear examples of the consequences of the constant search for an increase in international competitiveness while ignoring social indicators. The case of Mexico is, in this regard, very illustrative. Moreover, most nanotechnology initiatives are launched under the framework of the current patent regime that guarantees the monopolization of prices for 10 or 20 years. This has nothing to do with the satisfaction of social needs. The discussion related to neglected diseases is an example that brings light to this debate [12].

Second, the initiative to pay attention to the potential risks associated with nanotechnologies did not come from governments or enterprises, but from an environmentalist organization, the ETC Group. This took place in the World Summit on Sustainable Development in Johannesburg [8]. By disregarding these risks governments and enterprises made a clear statement on what interests or concerns they represent. The Investor Environmental Health Network (IEHN) published a report in [14], with a suggestive title, making reference to the tendency of industries to hide information relative to risks: *Toxic Stock Syndrome: How Corporate Financial Reports Fail to Apprise Investors of the Risks of Product Recalls and Toxic Liabilities*.

Third, most industrial sectors have pronounced themselves in favor of adopting voluntary codes of conduct [1, 5, 23]; and until 2007, most governments have adopted a similar stance. However, there is an exception: the insurance sector. This is because the companies in this sector need clear governmental regulation in order to function [25]. There is the case in which an insurance company has denied service to companies working with carbon nanotubes in the absence of a regulation issued by the government [3]. Another relevant case is that of retailers, since they have to delimit their responsibility from the firms that manufacture the products they sell. For that reason, sometimes they support the labeling of goods containing nanocomponents to inform the costumer. The report of the Swiss Retailer's Organisation & Innovation Society [26] endorses the initiative to label all products containing nanotechnologies.

Fourth, nanotechnologies have been strongly developed in those areas known as non-cost-sensitive. This is the case of military industry, since the matter of cost-benefit analysis in commercial terms is secondary or completely ignored [2]. To analyze the rest of the products containing nanocomponents it is necessary, for instance, to look at the database created by the *Woodrow Wilson International Center for Scholars*. One can discover that most of the products

are luxury goods. We can take one example from the textile industry. In this sector, most nanotechnology developments take place in the sport area, in which the costs can be prohibitive for the popular sectors.

If we take a look at the four previous examples we can observe that enterprises and governments endorse initiatives, actions or ethical positions that do not have a negative influence over economic benefits. But this is not true for all social sectors. The workers, in general, and the poor are not given a role to play in all this. Therefore, together with environmental NGOs and other social organizations, they better represent the interests of consumers. These groups also have a tendency to give priority to safety before commercialization, and they also give support to any research that results in the satisfaction of social needs over luxury goods for exclusive niches [4, 8–11, 16].

Conclusion

The two dimensions provide the necessary analytical tools to understand the ethical positions related to nanotechnologies and their responsible development. But, corrections that do not alter "the rules of the game" have very little to do with the reduction of inequality and poverty in the world. The socio-economic forces behind nanotechnologies are more likely to increase such inequality and poverty. Under the current momentum of crisis, a new technological revolution can be the alternative to increase the productivity of labor and thus capitalist profits. This can mean that benefits for the workers and consumers, if they ever come, are to be obtained in a very long term. It is logical to observe that the organizations of workers and environmental groups are strongly advocating "stopping" or decreasing the speed at which nanotechnologies are being introduced into the market. To these groups it is necessary to put health concerns, risks to the environment and labor above commercialization. In contrast, these topics of concern are not the focal points for the ones that are more likely to get benefits from the commercialization of nanotechnologies. Ethical and responsible nanotechnology development is not subordinated to technical rules but rather to the social forces that can reinforce adherence to systemic responsibilities.

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