Union perspectives on the risks and implications of nanotechnology

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Abstract

This chapter analyzes the positions of a group of national unions and international union federations on the risks and implications for workers of nanotechnology. Employing selected indicators, it examines the adoption of nanotechnology in industry world-wide and identifies the emergence of a labor force involved in industries that produce and make use of nanotechnology. It then offers a brief review of research on the implications of nanotechnology for labor that shows, on one hand, mounting evidences on specific risks posed by nanoparticles, and on the other hand, the potential for a transformation in the structure of work. Viewed in this context, it analyzes how unions have taken up the issue and what are their perspectives and demands. The research draws upon documental sources and semi-structured interviews with union leaders and technical advisors.
Keywords: nanotechnology, risks, employment, unions, workers.

Introduction

In this chapter I analyze the perspectives of unions from diverse regions of the world with regard to the development of nanotechnology, particularly concerning the specific implications for workers. The issue attracts increasing relevance since, in the previous decade, the number of companies developing or making use of nanotechnology across diverse industrial sectors has grown significantly, affecting a still-small, but gradually increasing quantity of workers.

The literature covering social aspects of nanotechnology and risks of nanoparticles identifies some of this new technology´s implication for labor. One on hand, it highlights the potential occupational risks to health associated with the toxicity of certain nanoparticles. On the other –although this issue has been explored to a lesser extent– it anticipates that the spread of this new technology and the obsolescence of existing products and processes will provoke

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instability in the labor market, displacing some workers and demanding new skills requirements in new or reconfigured jobs.

Through research based on documental sources and primary data obtained in interviews, I reconstruct the origins of the uptake by the union movement of the nanotechnology debate, their positions, concerns and demands. The documental sources consist of a set of 15 declarations proclaimed by unions through 2004-2010, in which the implications of nanotechnology are examined and demands are formulated. This information is complemented by eight semi-structured interviews carried out in 2011 with union leaders and technical advisors in unions from Brazil, Australia, Spain, France, and the United States, and by three international federations of unions from Latin America, Europe and world-wide.

In the first section, I provide some indicators that show evidence of the incorporation of nanotechnology in industrial processes and present the scarce, fragmented information available on the workforce involved in such processes. In the second section, I briefly review the literature on the implications of nanotechnology for labor. In the third section, I show that some of the unions have begun to discuss nanotechnology's implications for workers, focusing in the first place on the issue of occupational risks, and more recently, on the question of employment, and examine their perspectives and demands relating to those questions. I wrap up the chapter with brief conclusions.

1. The Industrial Development of Nanotechnology

In recent years, the number of products brought to market that contain nanoparticles or nanodevices has multiplied. An inventory of consumer products containing nanotechnology produced by the *Project on Emerging Nanotechnologies* of the Woodrow Wilson Center reported some 1317 products from 29 countries in March, 2011. The number of products increased about 521% since March 2006, when the inventory started (PEN, 2011).[2] The market of final products containing nanotechnology grew almost eight times between 2005, when it represented a USD$ 30-billion market, and 2009 when it reached USD$ 224-billion (PCAST, 2010:19).[3] Data drawn

[2] Although this inventory offers a good landscape of the rapid commercial development of products containing nanotechnology, it is not an exhaustive one. Details on what the inventory covers, and does not cover, as well as on the methodology employed to define and select products can be consulted in the Background and Disclaimer sections at http://www.nanotechproject.org/inventories/consumer/

[3] Certainly, these market values are still very far from the most optimistic estimates, such as that of Lux Research in 2004, and of Cientifica in 2005, that suggested a market of around USD$ 3-trillion by 2015. More recently, Lux

from various surveys, that gathered information on companies working with nanotechnology in Australia, Canada, Finland, Germany, Italy, Japan and the United States, indicate a potential to increase the marketing of products in the coming years (Palmberg & Miguet, 2009; ICE, 2009; NCMS, 2010; Murayama, 2006; Nanotechnology Research Institute, 2005).

Between 1990 and 2008, 17,600 companies in 87 countries participated in publications or patent registrations relating to nanotechnology (Roco et al., 2010:410). This indicates that a significant group of companies are presently, or potentially, developing or incorporating nanotechnology in their businesses. Among them one can find small *start-ups* through to large corporations, in high-technology industries and in more established and traditional sectors (Baker & Aston, 2005; Hullman, 2006; Cientifica, 2008; Youtie et al., 2009). The Nanotechnology Business Directory compiled by Nanowerk (2011a) identifies 2, 251 companies in 50 countries performing research, manufacturing or applying nanotechnology, while Helmut Kaiser (2007) counts some 1600 companies around the world working with nanotechnology. According to Palmberg & Miguet (2009), the inventory of firms by country show that a much larger number of companies exist than is reported in these international reports.

The rapid rise in the capacity and productivity of nanomaterial fabrication is another indicator of the industrial development of nanotechnology. The production of carbon nanotubes, a key nanomaterial, reached 65 tons per annum in 2004, sourced from 54 producers (Cientifica 2005). Near the end of that decade, a single leading-edge technology plant could produce between 300 and 500 tons per annum.[4] Despite the technical challenges encountered in process scaling up, other nanomaterials in high demand –presently 2809 different nanoparticles and nanomaterials are produced (Nanowerk, 2011b)– are likely following the same tendency as carbon nanotube production.

This convergence of indicators –the growing number of marketed products containing nanotechnology, the growth of their market value, the increase in the number of companies that develop or apply nanotechnology, and the rise in the productivity of nanomaterial production–

Research, taking into account the effects of the economic crisis, reduced their prediction to USD$ 2.5-trillion by 2015 (Hwang & Bradley 2010*).*

[4] Bayer Material Science brought online a pilot plant in 2010 to produce carbon nanotubes in Leverkusen, Germany, increasing annual production to 200 tons. The previous plant, which opened in 2007, produced 60 tons annual. *Nanocyl* installed a new reactor with the capacity to manufacture 400 tons annually of carbon nanotubes in Sambreville Belgium, beginning in 2011. *CNano*, with its headquarters in California and production facilities in China, built a plant with an annual capacity of 500 tons of nanotubes (Nanotech Wire, 2009; Plastics Today, 2010).

allow one to conclude that the use of nanotechnology in industrial processes is expanding. However, the data on the workers involved in these industries is, so far, scant and fragmented.

Roco (2003) estimated that through 2014, nanotechnology would create two-million direct jobs worldwide. This projection was recently updated to six-million jobs worldwide by 2020 (Roco, 2010). These are only estimates, and have merely considered the potential for job creation, but not for job losses due to likely labor shifts. So far there is no statistical data on workers in the area of nanotechnology. There is no job classification that allows the identification of those who are employed in nano industries as a specific category. Some of the data, although indirect, suggests that in the United States today, among researchers and workers, there are some 160-thousand nanotechnology jobs (Roco, 2010).[5] In Germany, 860 companies working with nanotechnology employed 63-thousand workers in 2008 and it is projected that this number will see another 43,200 new workers added by 2013 (BMBF, 2009).

Information is also scarce in relation to the activities undertaken by this labor-force. Studies based on information provided by companies in Germany, the United States and England all show that the larger part of the workforce employed in nanotechnology is made up of scientists and highly-trained engineers, which is consistent with the still-strong focus on research and development (R&D) activities. However, these studies also show that, accompanying the expansion in production and marketing activities, demand has surged for technicians and other qualified workers in manufacturing, quality control, marketing and documentation (Henn, 2004, cited by STOA, 2007; USDL, 2006; Godbe Research, 2006; Abicht et al., 2006; Sing, 2007; Lux Research, 2007; Van Horn & Fichtner, 2008; Aibithch, 2009; SEMPTA, 2009; Van Horn et al., 2009). The main professional requirements identified by the researchers were: interdisciplinary training to cope with the convergence of sciences on which nanotechnology is based; the mastery of new equipment and new techniques that allow the characterization of matter and manufacturing at the nanoscale; and a group of *soft skills* –already in demand in technologically complex and innovative processes– such as the ability to work in groups, to engage in continuous learning, and problem solving and communication capabilities.

2. Nanotechnology's Implications for Workers

[5] In-person interview, 1 Diciember 2010.

Nanotechnology is quickly being incorporated into productive processes and products without the potential risks having been evaluated. A considerable number of scientific articles suggest, however, that various nanoparticles have toxic properties. The International Council on Nanotechnology (ICON, 2010) at Rice University, USA, registered in their nanomaterial risk database, a sustained increase between 2000 and 2010 in the amount of articles published on nanomaterial risks to human health and/or the environment, totaling 563 by 2010. Another organization, NanoCeo (2010) (Nanotechnology Citizen Engagement Organization), produced a database that classifies scientific articles on risks according to the kind of nano-manufactured material. Between 2000 and the end of 2010, some 176 articles were gathered on the risks of carbon nanotubes; 190 on nanosilver risks; and 70 on the risks of titanium dioxide, all of which are materials extensively utilized in products that are currently available to consumers.

This research identifies various nanoparticles that have a high degree of toxicity and shows that carbon nanotubes can behave in a manner similar to asbestos (Takagi, 2008). The size of nanoparticles is so tiny that if inhaled, they can enter the respiratory pathways, through the blood barrier and reach the brain (Oberdorster, 2004). They can also cross the mother-fetus barrier (Wick et al., 2010). Nanoparticles have been show to affect cellular metabolism, even damaging or modifying DNA (Bhabra, 2009).[6] Many of these results were obtained through *in vitro* laboratory tests, or on animals, and it has not been proven that these effects are similar in human beings. At the very least, the currently available information can only reinforce the assertion that there is a reasonable doubt that certain nanoparticles carry risks for workers, consumers and ecosystems (Maynard, 2006; Kulinowski, 2009).

Workers are the social group perhaps most exposed to the potential risks of nanoparticles, from their first contact with them in the R&D phase in laboratories, through all phases of production and quality control in manufacturing plants, in transport, in marketing and, finally, in the collection and disposal of garbage (Schulte et al., 2008). A survey conducted among 357 companies and laboratories that developed nanotechnology in North America, Asia and Australia in 2006 revealed that although many firms follow general precautionary methods to protect workers, specific measures regarding nanomaterials are not being adopted, and only 25% of those had performed toxicology studies for the nanoparticles in use (Conti et al., 2008). According to another survey, carried out in 78 engineered nanomaterials companies in 14

[6] A further review of these studies can be found in Schulte & Salamanca-Buentello (2007).

countries, company representatives demonstrated a high degree of risk uncertainty (from 22% to 40% of them) across several types of nanomaterials, while 44% reported that nanomaterials pose moderate or high risk. Although 46% of the companies reported having a nano-specific EH&S programs, the research showed that most of such programs were not complying with the practices for handling nanomaterials recommended in several safety guidance documents issued by governments or international agencies.

Although the effects of nanotechnology development on employment have been under-researched, the issue was identified from the beginning of the discussions on social implications of nanotechnology. Crow & Sarewitz (2001) placed the risk of worker displacement, with the resultant broad social disruptions, as a recurring aspect of technological change that also applies to the case of nanotechnology. The ETC Group (2003) also referred early to the displacement of workers by the labor saving possibilities of new technologies and the obsolescence of professional qualifications.

Given that nanotechnology innovations are in great part directed to new materials creation, some research called attention to the effects of workforce displacement that could arise from a substitution of natural prime materials for nanotechnology-based materials. Two publications of the ETC Group (2005, 2008) conclude that a significant number of jobs could be at risk in countries that are highly dependent on the production of commodities. Drawing on case studies on rubber, textiles, silver and copper, they show how nanotechnology innovations could reduce the demand for those materials and the jobs in those sectors, initially affecting the countries of the South where such production is concentrated. Some of these countries, meanwhile, could take advantage of newly-arising possibilities to add value to commodities with nanotechnology. The Meridian Institute (2007), in a similar way, emphasized the potentially devastating socio-economic effect that a substitution of commodities could have on developing countries, while at the same time seeing an opportunity to improve the performance of some of the materials with nano-technological innovations. Sarma & Chaudhury (2009) studied the case of possible impacts of a change in the demand for copper on Chile and Zambia, two countries dependent upon the production of that mineral. Taking into account ongoing R&D projects that could lead to a substitution of this raw material, the authors concluded that the countries would experience negative economic consequences and job losses.

Invernizzi & Foladori (2010) and Invernizzi (2012) studied nanotechnology-based product innovation trends, examining products identified by the Project on Emerging Nanotechnologies inventory and products produced by Brazilian companies, to probe how such innovations could affect employment. They identified as significant trends the increased efficiency, prolonged duration and multifunctionality of products. The first result of these tendencies would be the substitution of existing products, creating instability among the producers and their employees. Multifunctional products tend to aggregate functions that had previously been delivered by different products –such as in the case of *nutraceuticals*, which combine medication, food and cosmetics in a single product– or to include maintenance functions that previously required specific activities –such as paint products that eliminate mold and self-repair damage; in stain- and wrinkle-free cloth; self-cleaning glass; etc. These innovations tend to reduce the amount of work required in production, maintenance and repair. The authors also found evidence of changes in materials used in new products based on nanotechnology, both natural raw materials and manufactured materials, which would lead to significant transformations in the sectorial structure of employment and in the regional/global division of labor.

3. Positions and Demands of the Unions

Various unions and union federations joined in the discussion on the implications of nanotechnology beginning in the mid-2000s, and since that time have published documents and made declarations on their concerns and demands. In a search of internet sources, I identified 15 of these documents, published by significant national unions in Europe, Latin America and the United States as well as large international union confederations (Figure 1). [7]

Figure 1- Union´s statements on nanotechnology

Date	Union	Country/Region	Declaration
July 2004	Trade Unions Congress	Great Britain	Nanotechnology Fact Sheet
August 2005	Australian Council of Trade Unions - ACTU	Australia	Inquiry into workplace exposure to toxic dust

[7] Undoubtedly there are other unions active in the discussion on nanotechnology than those cited here. I prioritized those unions that have made public their positions.

April 2006	ACTU- Australian Council of Trade Unions	Australia	Comment on DITR (Dept. of Industry, Tourism and Resources) Nanotechnology Strategy
October 2006	International Union of Food workers- IUF	Latin America	Nanotechnology- The IUF Resolution
April 2007	Civil Society – Labor coalition	International	Civil Society-Labor Coalition Rejects Fundamentally Flawed DuPont-ED Proposed Framework
July 2007	Coalition of civil society, public interest, environmental and labor organizations	International	Principles for the Oversight of Nanotechnology and Nanomaterials
October 2007	United Workers Central (CUT), Força Sindical, Brazilian section of ITUC and IUF and other social organizations	Brazil	Notes for a trade unions' position on the ethical, social and environmental impacts of the introduction of nanotechnology in food, products and processes
Jun 2008	European Trade Unions Confederation - ETUC	Europe	ETUC resolution on nanotechnology and nanomaterials
October 2008	Dutch Trade Union Federation - FNV	Netherlands	Occupational health risks of nanoparticles. Letter to the Minister of Social Affairs.
? 2008	Amicus- Unite the Union	Britain and Ireland	Unite the union's position on nanotechnology
April 2009	Australian Council of Trade Unions - ACTU	Australia	Nanotechnology – why unions are concerned
August 2009	Canadian Labor Congress	Canada	Nanotechnology: Small ingredients, big risks
March 2010	GRULAC/SAICM, IPEN and Int. Fed. of Chemical, Energy and Diverse Industries Union - ICEM	Latin American and Caribbean	Resolution on nanotechnology and manufactured nanomaterials
December 2010	European Trade Unions Confederation - ETUC	Europe	ETUC 2nd resolution on nanotechnologies and nanomaterials
December 2010	Canadian Union of Public Employees - CUPE	Canada	Health and safety issues with nanotechnology

Source: Elaborated by the author.

To expand on this information, I conducted eig'ht interviews with technical advisors and union leaders from three international union federations –the European Union Confederation (ETUC); the International Union Confederation (ITUC) and the Latin American Regional Union of Food, Farm, Hotel, Restaurant, Tobacco and Related Workers (IUF); three national unions – the Australian Council of Trade Unions (ACTU), the American Federation of Labor and Congress of Industrial Organization (AFL-CIO)[8], and Spain's Worker's Commissions (CCOO); and two unions in the chemical sector –the ABC Chemical Workers' Union, Brazil, part of the Worker's Central Union (CUT), through the Inter-Union Section of Statistics and Socioeconomic Studies (Químicos ABC-DIEESE), and the union of the Arkéma Lacq-Mourenx company, of

[8] Although AFL-CIO is mostly a US unions federation, there are some Canadian unions among its affiliates.

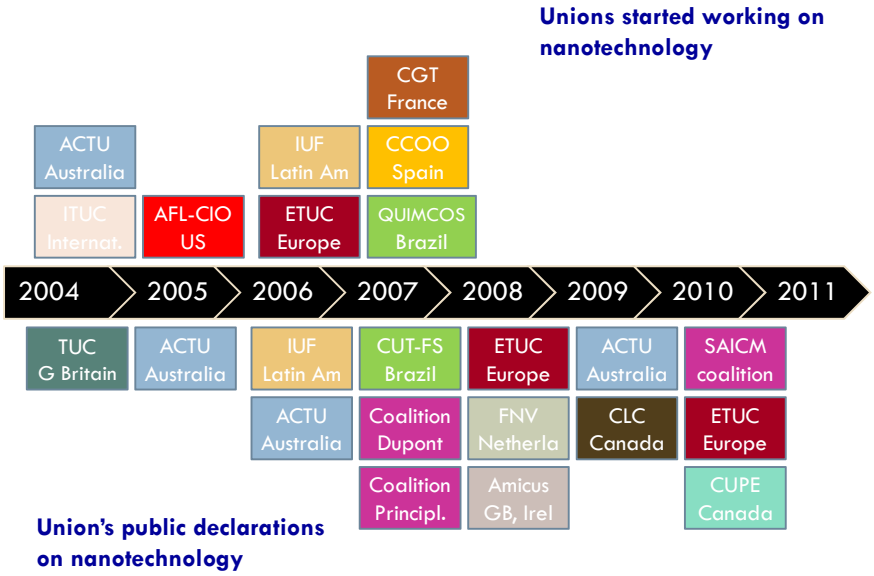
France's General Confederation of Workers (CGT). From this point forward, these interviews will be referred to as I1, I2... plus the union acronym.

Figure 2 shows, on a timeline in the upper portion, the moment in which large unions and federations began to be involved in the discussions around nanotechnology, according to data obtained in the interviews. This occurred between 2004 and 2007, a particularly active period in academic and civil society organizations discussions on the implications of nanotechnology. How did they come to take up this topic? According to the interviews, in Europe the Nanocap Capacity Building project[9] was of particular importance. Academics, NGOs, environmentalists and unions participated in the project, which brought together information from experts and stimulated unions to elaborate their positions on the topic. The union participants, for their part, influenced other unions, as is the case of the ETUC federation towards its members. In Latin America, discussions were stimulated by the contact with academic research networks on nanotechnology and society,[10] previous experience in campaigns relating to genetically-modified organisms (in the case of IUF), and the distribution of materials from NGOs such as the ETC Group. In Brazil, the role of Fundacentro (Occupational Health and Safety board of the Ministry of Labor and Employment) was key. In the same way, the AFL-CIO in the United States was influenced by the work of the National Institute for Occupational Safety and Health (NIOSH) as well as by the literature on occupational health. In Australia, ACTU joined the discussion by participating in a governmental agency that regulates industrial chemicals and through the nanotechnology campaign initiated by the NGO Friends of the Earth-Australia.

Figure 2 – Unions engagement with nanotechnology discussion

[9] This project was funded under the European Commission's program FP6 2006-2009. See http://www.nanocap.eu/Flex/Site/PagI4b9e.html?PageID=3493&Lang=UK

[10] Nanotechnology, Society and Environment Network – Renanosoma, Brasil (http://nanotecnologiadoavesso.org/), and the Latin American Nanotechnology & Society Network – Relans (http://www.relans.org).



Source: Elaborated by the author based on Unions´ public statements and interviews.

The lower portion of Figure 2 shows that once the theme was incorporated into the union's agendas, they quickly began to make their views known publicly, through the aforementioned declarations. In four cases, the declarations were signed jointly with other social, environmental, consumer, chemical-control, social justice organizations. However, this rapid reaction did not translate into a wide mobilization of unions around nanotechnology. The interviews showed, consistently, that the level of information and the involvement of member unions and base organizations on the topic is still incipient, and in some cases, nonexistent. Therefore, union activism around nanotechnology is still very much restricted to the leaderships and to the workers and technical staff that work in occupational health and safety. All in all, these unions are making the effort to get the word out, including the publication of information on web pages and publications and the organization of seminars.

The declarations analyzed differ in format, scope and in the context in which they were created, but have in common the concerns of unions over the development of nanotechnology. To that end, they offer data, arguments, cite scientific studies and –frequently– put forward demands to governments and call for unions and unionists to take up the issue. These declarations are examined together, highlighting the issues that are present across the majority of the documents. One can see, in Figure 3, the main matters of concern to unions: that

nanotechnology carries risks to health and the environment; that it is being introduced into productive processes without taking preventive measures in the workplace and before the establishment of standards that guide any such preventive practices; that there exists very little knowledge on the previous two questions; and the dearth of regulations.

The social and ethical implications of nanotechnology are also frequently mentioned, while concrete statements around employment and worker training were made only in three of the declarations. In the interviews, I noted that while the related themes of risks and worker safety were treated in a concrete way, having been discussed, analyzed and generated specific responses, the social implications of nanotechnology, including the effects upon employment, tended to be considered in a more generic manner.

Figure 3 – Matters of concern addressed in union´s declarations

Trade Unions	Health and environmental risks	Lack of workplace safety measures	Need of nano-specific regulation	Insufficient knowledge	Social and ethical implications	Effects on jobs and skills
TUC, UK	✓	✓	✓	✓		
ACTU, Australia *	✓	✓	✓		✓	
IUF, Latin America	✓	✓	✓	✓	✓	✓
CUT, FS, CSO** and others, Brazil	✓		✓	✓	✓	✓
CSO – Labor coalition, International	✓		✓		✓	
CSO, Labor and others, International	✓	✓	✓	✓	✓	
ETUC, Europe *	✓	✓	✓	✓	✓	✓
FNV, Netherlands	✓	✓	✓	✓		
Unite, Britain and Ireland	✓	✓		✓		
ICEM, CSO and others, L. America & Caribbean	✓	✓			✓	
CUPE, Canada	✓	✓	✓	✓		

Source: Elaborated by the author based on union´s declarations.
* In the cases of ACTU and ETUC, that produced more than one declaration, they were considered together.
** CSO – Civil Society Organizations

The primary attention given to the theme of risks –highlighted throughout all of the documents– and related issues such as protection measures and regulations, is explained on the one hand as a reflection of the development of nanotechnology and the actions of different social

groups. Of greatest importance was the influence of the academic and social organizations discussions, which framed the risks of nanotechnology as a problem of health, environment and, also, as an ethical matter. In 2002, the call for a moratorium by the ETC Group, claiming evidence on the plausible risks and the need to conduct further research, ignited the public debates on nanotechnology, provoking polarized stands. Two years later, a report published by the Royal Society and the Royal Academy of Engineers contributed to the legitimization of the issue of risks and called for further studies (RS&RAE, 2004). As was shown earlier, the evidences on the toxicity and adverse affects of some nanoparticles increased throughout the previous decade. The unions, in various public declarations, regularly cited the research on risks published in prestigious scientific journals, to give greater force to their positions. In this context arose the initiatives toward voluntary regulation proposed by large companies such as DuPont, Bayer, BASF, Johnson & Johnson, and UNILEVER, attempting to get ahead of government-led regulatory measures, which generated critical reactions from various unions and social organizations. Finally, some unions are accompanying the discussions on regulation in the European Commission and the OECD, started in 2007. The ETUC and ITUC federations took part in that process.

If, on the one hand, all these events have been important for unions to prioritize the questions of risks and regulation, on the other the willingness of unions to engage the topic has been strongly determined by their historic experience, which has left them in a state of alertness. The interviews conducted revealed that the unions, in different geographic and political contexts, fear "repeating history." They worry that nanotechnology will be transformed into a new asbestos. In the United States, the interview with the AFL-CIO emphasized that, despite the history of illness and worker deaths caused by toxic materials, nanotechnology is still being rapidly introduced without any prior analysis of risk, placing workers in the role of experimental subjects:

> *We don't have a regulatory framework in this country that says that when introducing new chemicals …we have to get some basic information on the hazards of those materials. ….. So, you know, you are kind of working blind, you have no idea, and this has been the whole history of occupational safety and health, at least for chemical hazards. And after 20 years, 30 years, 40 years of use, all of a sudden, oh yes! you know this is a killer, causing serious illness and deaths of workers. And now we have the evidence, we have a lot of human bodies, we have a lot of workers who died, and then a lot of scientific publications say yes, this stuff is really nasty, and then we'll do something about it.* (I6, AFL-CIO).

The lack of transparent information on the part of companies about the use of nanotechnology is seen as a repetition of previous behavior in relation to the imprudent introduction of materials without sufficient testing. The interview with the ITUC, which counts unions from 151 countries in its membership, states:

> *We are in an environment of growing concern vis-a-vis the transparency capacity of companies to reveal information concerning health hazards. The feeling I get from many unions is "we don´t want to repeat an asbestos case". We have this feeling that we might be repeating history, and this is a very frustrating feeling for many unions.* (I2, ITUC)

Likewise, the ex-Secretary General of the Latin American section of IUF emphasized that nanotechnology is being introduced in a context of little protection for the health of workers in the region:

> *Our position is one of precaution. And why precaution? Because... all of this exists within a context. And, under what framework do nanotechnologies and their possible risks appear? ... According to the ILO and the WHO, in Latin America 30-million workplace accidents occur every year (2009 data). These result in 240-thousand deaths annually. That is to say, there are 657 deaths daily, the majority of these are due to accidents at work. Obviously workers are not suicidal! These are due to employer negligence, that in order to cut costs they don't implement proper protection measures.* (I3, IUF).

If we consider some of the paradigmatic cases of illnesses arising from work environments –silicosis, cancer due to asbestos and toxic exposure to lead– it is evident that unions have valid reasons to face nanotechnology with such distrust. In the three cases, workers were exposed to the adverse effects without adequate protection over decades and the companies, systematically, hid information or sought to delay the introduction of regulatory measures. Well-known since antiquity, silicosis was identified around 1925 as a professional pulmonary disease caused by the inhalation of silica powder. That awareness didn't prevent the negligence shown in the tragedy of *Hawk's Nest*, in West Virginia, USA, in which some 2000 workers died of silicosis a few months after they had started digging a tunnel for *Union Carbide* in the 1930s. A contractor who hired the workers said at the time: "I knew I was going to kill those niggers, but I didn't know it was going to be this soon" (cited in Rampton & Stauber, 2001:77). Only in the 1980s was the matter investigated and responsibilities imputed. Still, even today, the United States has no comprehensive standard to protect workers from silicosis (I6, AFL-CIO).

Poisoning by lead contained in paint and gasoline is another case known since the early 20th Century. However, the industry managed to delay for decades the establishment of regulations, some arguing that the adverse affects were caused by "sloppy and careless workers" (Markowitz & Rosner, 2002). Indications that asbestos was a powerful cause of cancer and lung disease were likewise identified at the beginning of the century, but companies tended to hide information about the seriousness of the matter (Michaels & Monforton, 2005). Presently, annual deaths in North America related to asbestos reach 10,000 people, and the National Institute for Occupational Safety and Health (NIOSH) in the USA estimates that exposure to allowed levels of asbestos currently lead to five deaths by lung cancer and two by asbestosis for every 1,000 workers during their lifetimes.[11] In that historic context, considering the rapid advance of the production and commercialization of products containing potentially harmful nanoparticles, and the lack of transparency of information, the unions are newly concerned that the evaluation of risks and the establishment of protective measures will come too late for workers.

In Figure 4 can be seen the main demands made in the declarations and which organization support them. The unions are dealing with a situation of uncertainty in relation to what risks exist, given that research is still in preliminary phases. "Our concern –said one interviewee– is that we know that much more research is needed about the risks of nanomaterials on workers' health and for the environment" (I5, Químicos ABC-DIEESE). It is for this reason that they demand governments, and in particular the programs that drive nanotechnology development, direct more funding to investigate the risks in a way that could determine more clearly the potential benefits and risks. For example, the declaration of the Canadian Labour Congress (2008:2) affirm: "Toxicological research must keep pace with technological research, even the most promising discoveries should never be developed if the risks to health or the environment are proved to be unacceptable." The call for research goes beyond toxicology, since those who work in the unions' health and safety commissions want to know where nanotechnology is being applied in order to put into effect preventive strategies. "What are the possible applications of nanomaterials? What is the degree of market penetration? What companies are developing nanotechnologies?" –asked our interviewee form Spain's Workers Commissions (I7, CCOO).

[11] See http://www.mcclatchydc.com/2010/07/21/97624/asbestos-us-legacy-may-be-half.html#ixzz1c6X6irw1

Figure 4 – Main demands regarding risks in union's statements

More research	Broad discussion/ participation	Specific Regulation	Transparent information	Precautionary approach
ACTU 2005 ACTU 2006 CUT, FS 2007 IUF 2007 CS-L Coal 2007 Coal Principl. 2007 FNV 2008 ETUC 2008 AMICUS 2008 ACTU 2009 CUPE 2010 ETUC 2010	ACTU 2005 ACTU 2006 CUT, FS 2007 IUF 2007 CS-L Coal 2007 Coal Principl. 2007 ETUC 2008 AMICUS 2008 ACTU 2009 CUPE 2010 ETUC 2010 SAICM 2010	ACTU 2005 ACTU 2006 CUT, FS 2007 IUF 2007 CS-L Coal 2007 Coal Principl. 2007 FNV 2008 ETUC 2008 ACTU 2009 CUPE2010 ETUC 2010	ACTU 2005 ACTU 2006 CUT, FS 2007 Coal Principl. 2007 FNV 2008 AMICUS 2008 Unions Tas. 2009 CUPE 2010 ETUC 2010 SAICM 2010	ACTU 2006 CUT, FS 2007 IUF 2007 Coal Principl. 2007 FNV 2008 ETUC 2008 ACTU 2009 ETUC 2010 SAICM 2010

Source: Elaborated by the author based on union´s declarations.

With the same intensity, unions are demanding participation in discussions where workers can play an effective role in the definition of strategies and control of nanotechnology risks. In a document produced by English union TUC and in the document Principles for the Oversight of Nanotechnologies and Nanomaterials, the need for protection for participants is stressed, insisting that workers and their representatives can be involved in the activities that promote safety in the workplaces without fear of retaliation. Even in the cases where unions have been invited to participate or have struggled to take a role in discussion forums, they are far from having any significant role, due principally to the lack of technical staff. ETUC, for example, has participated in key spaces, such as the working groups on regulation in the European Commission. However, the interviewee confirms that

> *It is difficult to participate, as we need experts in the field, and the experts are located within the industry, working for it. For the unions it is very difficult to find experts who can represent us, or who can simply read all of the research which is very technical, and understand the problem and possible consequences (I1, ETUC).*

The ITUC interviewee expressed a similar perspective: "There is a difference between being invited and participating and having an active role", and exemplifies with the case of their involvement in the negotiations on nanomaterials in the OECD, where the discussion level is "deliberately highly technical", which restricts the union's ability to engage:

> *Our participation is still limited in terms of numbers and limited because technical constrains. The great majority of the debate is done between nano experts and this makes our approach very difficult, our intervention is very difficult ... to express something that matters aside from general concerns, because the reality is that we don't have sufficient data on risks, and we don't have sufficient data on positive*

> *aspects either. On other issues, with chemicals, we go to a negotiating table with data, we have data, we know. With nano is much more "we want the precautionary principle", "we would like you to take this into account", " we want consultation", " we want participation", " we want democracy". And they always reply: "Well it is not here, here we only deal here with the technical aspects of nanotechnology", so sometimes it is like talking to a wall.* (I2, ITUC).

Similarly, in the United States, although the organization has been invited to participate in various activities by the government agencies that work on occupational health and by the National Nanotechnology Initiative, that participation has been highly restricted because, according to the AFL-CIO interviewee, there are today only two persons from the unions involved in the theme at the national level (I6, AFL-CIO).

In Australia, differences between industry and unions were more stressed than technical difficulties when it comes to the union participation in discussions. The ACTU has had an active participation in the government agency that regulates industrial chemicals, which involves societal representatives such as unions and environmental groups, together with industry and government, and where the regulation of nanotechnology is under discussion. The ACTU delegate noted that, while the government has facilitated workers' participation, the industry lobbyists are attempting to convince the government that unions are exaggerating the risks associated with nanotechnology, and placing obstacles in the way. This has created some concern among government officials that Australia could be left behind in the pursuit of nanotechnology (I4, ACTU).

In Brazil, Spain and France, the unions interviewed had not been formally invited by the government to nanotechnology discussion forums. In Brazil, the ABC Chemical Workers' Union managed, however, to insert itself into the discussions at the Forum on Nanotechnology Competitiveness, created late in 2009, as a tool for industrial policy (I5, Químicos ABC-DIEESE). In France, unionists have participated in public discussions about nanotechnology convened by the government, but not as union representatives (I7, CGT).

It is interesting to highlight that the lack of experts on the theme has led some of the unions to join forces with NGOs, as it happened in the case of ETUC, ITUC, IUF, ACTU, AFL-CIO and the ABC Chemical Workers. Such cooperation has resulted in some joint declarations – such as in the rejection of the proposed voluntary regulation by DuPont, the Principles for the Oversight of Nanotechnologies, and the Guidelines for Unions Actions on Nanotechnology in

Brazil. Union representatives have also stated in the interviews that they frequently make use of informative material produced by NGOs. Since many of their concerns are mutual, it is possible that such collaborations could lead to stronger future alliances.

Another demand that arises frequently in the union declarations is the establishment of mandatory regulation specific to nanotechnology. The Australian national worker's union stated in a document: "Unions agree that nanotechnology has important potential, but argue that regulation is needed. Despite the growing evidence to show that nanomaterials present unique health and safety hazards, no country has introduced nano-specific regulations. Regulators, including Australia, rely on regulations that weren't designed to protect workers against nano sized materials." (ACTU Fact Sheet, 2009:1). Similarly, the declaration of the public employees' union of Canada warns: "The biggest concern for workers is that the rapid advancement of nanotechnologies has outpaced government's ability to control and regulate it. There are no regulations to protect workers exposed to potentially harmful by products of production. There are no controls for nanopolution, caused by the breakdown of products containing nanoparticles in our landfills." (CUPE, 2010:1-2). This perspective is repeated in the majority of the documents reviewed, and was particularly emphasized in the declaration rejecting voluntary regulation signed in 2007 by unions (AFL-CIO, IUF, and the USW - United Steelworkers of America) and various social organizations regarding the proposal put forth by DuPont and the NGO Environmental Defense. A much wider coalition of unions and social organizations soon after identified mandatory regulation as one of its Principles for the Oversight of Nanotechnologies and Nanomaterials (2007). Various interviewees remarked that the proposal of some governments to ask companies to voluntarily declare their nanotechnological activities had failed. The Dutch Trade Union Federation exposed the contradiction between voluntary registration and the firms' right of confidentiality: "Attempts to organise employers and manufacturers on a voluntary basis to report the use of nanoparticles in products failed so far, because of the voluntary character. Manufacturers and suppliers hide themselves behind the argument of confidentiality" (FNV, 2008). On this point, the position of the first document issued by the European Trade Union Confederation accept voluntary initiatives under certain conditions: "The ETUC believes that Industry Voluntary Initiatives and Responsible Codes of Practices may serve a useful purpose pending implementation of the necessary changes to the current legislative framework and/or the introduction if need be of specific new European

legislation to support responsible nanotechnology development. However, the ETUC is prepared to endorse such initiatives only if the signatories undertake to involve workers' representatives in their design and monitoring, if there is an independent and transparent system for assessing compliance (e.g. by involving labour inspectorates) and if sanctions are foreseen in case of non-compliance." (ETUC, 2008:6).

Given the lack of specific regulation, the evidence of risks shown in some research, the need for more studies and the historical experience of risks in workplaces, the unions claim the application of the precautionary principle. IUF's resolution calls on "governments and corresponding international bodies to apply the precautionary principle, prohibiting the sale of foodstuffs, beverages and livestock feeds, as well as all the agricultural inputs that incorporate nanotechnology, until it is shown that they are safe and abide by an international regulatory regimen specifically designed to analyze those products" (IUF, 2006:1). The document published by ETUC (2008) reinforces that "preventive actions should be initiated when uncertainty prevails. This means that the precautionary principle must be applied. This is an essential prerequisite for the responsible development of nanotechnology....", and links the application of this principle with that contained in the European REACH legislation that states "no data, no market". Reflecting on the history of workplace risks, the representative of the AFL-CIO offered a mix of hope and doubt, saying:

> *"I think that we have an opportunity actually with nanotechnology to put in practice the use of precautionary approaches ... or we are not going to do anything until it shows that this stuff is harmful to workers? The market is expanding so rapidly... We still have an opportunity to do that, but I am not so sure... doing it differently! doing it better! and trying to do it right and not wait as we had before"* (I6, AFL-CIO).

As unions officials noted in the interviews, a specific problem lies in how to advance specific demands to make the precautionary principle operational in workplaces where nanotechnology is being developed or used. The European trade unions involved in the NanoCap project worked on this issue and came up with some concrete recommendations such as: no data-no exposure, no emission; mandatory reporting of nanoparticles content in products; registration of workers exposed to nanomaterials; transparent information of known and unknown risks; derivation of workplace exposure limits; development of an early warning system and

premarketing approval for all applications containing nanoparticles or nanomaterials (Broekhuizen & Reijnders, 2011).[12]

Lastly, for workers it is essential that transparent information be made available on nanotechnology development, its risks and its use by companies. The interviewees highlight the role that governments have in the provision of transparent information and the pursuit of specific studies that allow for an assessment of whether workers are exposed to risks. They strongly express their concern over the resistance by companies to provide information to workers and unions on the application of nanotechnology to production processes. Thus, for example, the Latin American federation that covers the entire production chain and the consumption of foodstuffs estimates that "some 200 manufacturers of foodstuffs are undertaking research and development in nanotechnology... As the food industry does not make public their use of nanomaterials in their products and there exists no obligation to label those products to inform of the use of nanotechnology, it is possible that the use of nanotechnology in food production is much more prevalent than is known" (I3, IUF). The current situation, as observed by the ITUC representative, is that "many workers could be working with nano[materials] without knowing it, which is an enormous concern..." (I2, ITUC).

For the ex-Secretary General of the IUF, the workers´ right to information is inseparable from the collection of fundamental rights in which union freedom is based, and notes some of the clauses that protect that right. The ILO supports the right of workers to information on the activities of companies that are relevant for the negotiation between capital and labor, in accordance with Convention 154/1981 about Collective Bargaining. In the Tripartite Declaration of Principles on Multinational Companies and Social Policy of the ILO, multinational companies and governments must provide to worker representatives information required to hold efficient negotiations. The guidelines of the Organization for Economic Cooperation and Development (OECD) also require companies to provide worker representatives with the information needed to pursue constructive negotiations on working conditions. Backed by these resolutions, the IUF has recommended to unions of large transnational food industry companies that they include a clause in their collective agreements that require the companies to inform them of any use of nanotechnology. Besides, the ABC Chemical Workers Union in Brazil required the inclusion of

[12] FNV, along with another Dutch union, the National Federation of Christian Trade Unions (CNV), and the Confederation of Netherlands Industry and Employers negotiated some protective measures based on the Precautionary Principle, including some pilot nano reference values of exposure (SER, 2009).

a clause in their collective agreement in that the companies must report to the Internal Commission of Accident Prevention and to the union regarding the introduction of nanostructured materials, as well as information on risks and protective measures. Opposed by the employer, this negotiation managed to obtain a recommendation that the theme of nanotechnology be taken up in the Week of Accident Prevention in the chemical and pharmaceutical industries, a mandatory annual one-week training activity for all companies (I5, Químicos ABC-DIEESE).

I now turn to examining how the unions have taken up the matter of implications of nanotechnology on employment. Three unions deal with this issue in public statements. In two of their declarations, ETUC (2008 and 2010) focus on the potential for job creation, the required qualifications profile, and the possible displacement of workers. IUF (2006) called for the International Labor Organization (ILO) to begin studies on the potential impact of nanotechnology on working conditions and employment in agriculture and the food industry, and to later convene a three-party conference to discuss the matter. Brazilian unions published a document in 2007 highlighting in particular the potential substitution of commodities by products based in nanotechnology, which could eliminate thousands of jobs. Another six declarations stated that nanotechnology could affect workers in their workplaces, as citizens and as consumers, without expounding further on the issue.

Let's see the question in greater detail. Among the two declarations of ETUC in 2008 and 2010 can be seen a change in perspective. While in the first the potential for nanotechnology to create employment was emphasized, so long as its development was pursued in a transparent and responsible way, in the second declaration the federation adopts a more skeptical posture. The document warns that the job creation scenario could not be so promising and that the restructuring of production, with its related changes in employment, could generate new inequalities among workers. Given the timing between the two declarations, the rise of the economic crises weighed on this change, but so too did the growing preoccupation about health risks. Thus, for ETUC it is important that any jobs created by nanotechnology be safe in two aspects: the health of workers and employment stability. With the growing crisis, expectations for employment creation were reduced, and it is thought that any new jobs could be reduced to a highly restricted group of specialized workers, with high qualifications, while other workers end up being displaced (I1, ETUC).

The ITUC undertook a similar process, according to the interviewee of this global federation of unions (I2, ITUC). Aware of the extreme global inequality in conditions of work, the initial optimistic view of nanotechnology as a potential job creator has given way to a more contradictory perspective, as discussions on the topic move forward. The interviewee stated that for some well-organized sectors such as chemicals workers, nanotechnology could represent new job opportunities. Other workers see possibilities of rejuvenating industrial sectors that have been in decline, such as automobiles, construction materials, etc. A new element in the nanotechnology discussions –she stated– is that "…we are not just buying the employment generation argument without considering the OHS [occupational health and safety] issues and impacts that is something that we have done in the past." The ITUC developed a platform for the orientation of unions in dealing with structural changes in the economy, to ensure that such transitions are fair in social terms, and this platform may assist workers in confronting changes caused by the development of nanotechnology.

Other unions have taken up the discussion on nanotechnology's implications for employment to a lesser degree, for different reasons. From the point of view of the interviewee from the AFL-CIO (I6, AFL-CIO), this will be a key question in the future, if current projections for nanotechnology prove true. However, according to him, despite the leadership position of the United States in nanotechnology, it is likely that none of the 55 union members of the AFL-CIO are engaged with this topic, and if some have taken it up, it is a very limited discussion. He credited this situation to two factors: on the one hand, the lack of information. Neither unions nor workers receive information on nanotechnology from the companies that develop or employ them. On the other hand, he argued that nanotechnology is not seen by workers as a revolutionary technology, because it is not noticeable in the workplace, or because it is contained within familiar things:

> *When you read the press, or stuff coming out from the US government's NNI [National Nanotechnology Initiative], they talk about a nanotechnology revolution, but I don't think that at the shop floor level, at the workplace, people see it at all as a revolution, if they see it at all! They see new materials, we have seen new materials over the years, and this new materials happened to be new materials with something called a nanoparticle in it, whatever that means, and they don't necessarily know what that means. So, I think that there is a basic lack of knowledge on this whole … if you want to call it a revolution… this whole technological development is all about.*
> *[previous technological changes were about] a new machine we never had before, a new version of a machine that does a lot more. And here it is … nanomaterials into a tennis racket or golf club! You may not be aware of it…"* (I6, AFL-CIO)

According to the IUF representative, another factor that contributes to the scant discussion on the theme is that workers are already overwhelmed by more tangible and urgent employment challenges (I3, IUF). Many jobs in Latin America and the Caribbean are threatened by outsourcing practices and for the deregulation of the labor market. Thus, he affirmed, although the risk of losing jobs due to nanotechnology exists, it is handled as a distant problem in the face of more pressing matters. Therefore, the IUF has decided as a strategy, to first focus on the question of workers' health risks, leaving the employment problem in second place. Also in Latin America, the ABC Chemical Workers' Union is in an initial state of discussions on the matter. The key concern –since the chemical sector is one of the most active in the development of nanotechnology in the country– is that this process be accompanied by training and that the increases in productivity achieved translate into better working conditions for its members. Otherwise this new technology could deepen the already significant inequality of the Brazilian labor market (I5, Químicos ABC-DIEESE).

Although it has been a highly active union in the discussion of the risks and regulation of nanotechnology, the Australian national workers union has not engaged the theme of employment as it relates to nanotechnology. The representative interviewed (I4, ACTU) considers that only a restricted circle of people within the unions "have a sense that this is going to be big, not only these things we read about like socks that don't smell ..." The concern is that since nanotechnology is unfolding so rapidly, unions will arrive too late to an understanding of the true dimensions of this phenomenon.

The interviewee from France's CGT works in a plant that produces carbon nanotubes, one of the materials presented as most promising and about which there exists a growing concern about the adverse health affects for workers and the environment. In that context, he framed the question in a radical way:

> *The question of employment is related to the products that are produced. What is the interest in having more employment if we're going to lose our lives? For us, it has to be a safe product, if not, we won't make it!* (I7, CGT).

Conclusions

Since the beginning of this century, nanotechnology has begun to be incorporated into the industrial processes. Presently, it is mostly a matter of incremental innovations that show up in

materials and products with new characteristics and functionalities and increased performance. A potential for greater transformation lies in innovative tendencies that are developing in the laboratories. Even if this phenomenon is only at its beginning, its pace cannot be minimized nor the degree of development that has been achieved so far. Both questions are fundamental in terms of evaluating the implications of nanotechnology for labor.

Nanotechnology has appeared in commercialized products extremely quickly, overrunning the under-financed research on its potential risks for health and the environment. The regulatory vacuum has certainly facilitated this outcome. The growing number of companies that develop or use nanotechnology, the variety of productive sectors involved, and the wide territorial reach, reveal a development of global dimensions, although with blatant gaps between countries and regions. In this way, the advance of nanotechnology will affect workers who find themselves in disparate situations of union organization, quality of employment, conditions of life and citizen rights.

The global reach of nanotechnology development is reflected in the convergence of unions, across very diverse regions, on the concerns and demands regarding nanotechnology effects on labor. The primary concern lies with the exposure to risks that have been scarcely researched. Workers fear that conventional protective measures at the factory level may not be effective and demand research that help determining exposure limits to nanoparticles. They ask for the application of a precautionary approach and the discussion and enforcement of regulations. The history of harm caused to workers by untested substances introduced into the production process is constantly remembered, which, added to the frequent lack of transparency on companies' information, has put unions in a state of alert.

The potential implications of nanotechnology for employment have deserved limited discussion within unions so far, whether because it is still not perceived as important (Australia and the United States), whether it is because unions are overwhelmed with existing problems and it seems to be a long-term concern (Latin America). Only in Europe has the topic begun to be discussed, where a transition can be seen from optimism over the possible creation of jobs to a more cautious position that fears the consequences of an industrial restructuring in a context of crisis.

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