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Dr. Kübra İRDAY DEMİR
Dr. Pervin Zülfigarova

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METHODOLOGICAL APPROACH TO THE REVIEW OF NANOTECHNOLOGY PRODUCTION CHAINS IN MEXICO

LATIN AMERICAN NANOTECHNOLOGY AND SOCIETY NETWORK (ReLANS)
PROYECTO CONACYT – CIENCIA DE FRONTERA 304320

Dr. Edgar Arteaga Figueroa
Autonomous University of Zacatecas
Academic Unit of Development Studies
ORCID: 0000-0002-1430-3091

Prof. Dr. Armida García
Autonomous University of Zacatecas
Academic Unit of Development Studies
ORCID: 0000-0002-9375-1027

Prof. Dr. Guillermo Foladori
Autonomous University of Zacatecas,
Academic Unit of Development Studies.
ORCID: 0000-0002-7441-3233

ABSTRACT

Since the beginning of this century, nanomaterials have been fabricated and applied in devices and final products, almost without restrictions, regarding their new functionalities. A methodology to identify companies and its outcome in a sectorial economic list was carried out to analyze nanotechnology companies in Mexico.

The research was divided into two stages. The first one was the elaboration of a path for an exhaustive search of companies from different sources, which ended up in an inventory of companies that manufacture or sell nanoenabled products in Mexico. In addition, geographical location of the company was obtained through the address of its central offices in Mexico. This allowed to stablish a distinction between companies that carry out "national production" and those that "import and retail within the country".

The second stage assigned each company a sectorial economic classification, taking as a starting point the Central Product Classification System (CPC), from the United Nations (UN). Due to the great diversity of products found, equivalence was established between the CPC and the fourth revision of the International Standard Industrial Classification System for all economic activities (ISIC 4).

When the concordance between CPC-ISIC 4 was applied, it was possible to establish an equivalence of these products with those of the ISIC divisions, helping a simplified economic classification in just over twenty sectors. The information allowed us to locate companies into

a production chain Distinguishing nanomaterials from nanointermediate products, from nanoenabled final goods, and from nanotools.

Keywords: Nanotechnology, Production chains, Inventory of companies, Sectorial economic classification

INTRODUCTION

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers in at least one dimension (NNI, n/d). At this scale, matter can exhibit physical, chemical, optical, and biological characteristics other than at its macro size. Nanomaterials offer amplified quantum properties that can be exploited in the development of novel industrial applications.

By changing some of their functions, nanomaterials can be used industrially in innovative ways and compete advantageously in many sectors and aspects. For this reason, they are known as general purpose or enabling technologies (Roco et al., 2010) as they have applications in all economic sectors and radically affect scientific platforms and industrial activities.

Over the last 20 years, several countries have significantly increased the budget for Research and Development (R&D) of nanotechnologies from public and private sectors (NNI, 2018). Emerging nations in Africa, Asia and Latin America have joined the nanotech wave. The implementation of public-private partnerships, the so-called spin-offs appear as a common strategy because of the uncertainties of its outcomes that make big companies to be reluctant to invest until a promissory result is attained.

The first time that nanotechnologies appeared on the Mexican political agenda was in the Special Science and Technology Program (PECyT) 2001-2006, where they were called an area of interest for research, specifically by the Mexican Petroleum Institute (IMP) (CONACYT, 2002). Government seek to integrate universities, public centers, private companies and government institutions in order to develop nanotechnological capacities. However, there is still a significant gap in the systematization of information related to the development of these technologies in Mexico. This is due to the lack of a public observatory to follow up the development of this technological package.

Nanotechnology has been strongly incorporated into industrial processes since the early years of this century. Today it can be found in most, if not all, economic sectors (Tsuzuki, 2009). Nanomaterials have entered the market as raw materials, devices and also in final products with practically no restrictions, beyond those that the regulation of chemical products applies to the same materials in larger size.

Facing this accelerated growth, and given the possible risks for health and the environment of these technologies, the need arises for public registries, inventories of companies and nanotechnology products that allow monitoring these technologies. This would make possible to determine key economic sectors of application, avoiding duplication and using public funds

more efficiently. Then, an inventory of companies is the starting point in the design of a nanotechnology public policy.

METHODOLOGY

The first stage of the research consisted of elaborating a methodology for an exhaustive search of companies that make or sell nanomaterials, nanointermediate devices and nanoenabled products in Mexico. For this purpose, two previous inventories were taken as a basis: Nanotechnology companies in Mexico: towards a first inventory (Záyago et al., 2013) and Sectorial economic analysis of nanotechnology companies in Mexico (Záyago et al., 2015). These are followed by an actualization and upgrade. In these cases, information was obtained from different sources:

- Company website, privacy notices, terms and conditions, Internet, radio and television advertisements: the company explicitly mentions that it makes or sells nanoenabled products.
- Specialized parks: website of the Nanotechnology Cluster of Nuevo León and the Government of the State of Nuevo León (Mexico).
- Transparency portals on the budget used by companies in nanotechnology projects. Website of the public information system on public procurement (Compranet).
- Press bulletins, scientific and popular articles in academic journals where it is reported that the company participated in a nanotechnology project.

We first detected the product or products with nanotechnology that the company places on the market. In most cases only one product is advertised. When more than one was found, we selected the first one identified.

In addition, we obtained geographical location of the company through the address of its central offices in Mexico, and stablished a distinction between companies that carry out "national production" and those that "import and retail". It was verified the existence of a physical headquarters in Mexico and manufacturing of nanomaterials, intermediaries and products within the country. The first criterion is the explicit declaration of being a company with operations in national territory, as well as the physical geographic location of a production plant. In addition, it was identified whether:

- They make purchases and/or are provided by companies that manufacture nanomaterials within the country.
- They request services for the synthesis, measurement and testing of materials from nanomaterial companies that manufacture in Mexico.
- They belong to a specialized technology park (Nanotechnology Cluster of Nuevo León).

On the other hand, most of the companies that "import and retail" do not have a physical headquarters in Mexico, or else have a wholesale or retail sales office in specialized trade, where the company claims to be an importer of products that contain nanotechnologies for sale within the country. In addition, there are retailers that sell their nanoenabled products only through online orders. We identified whether it is manufactured in another country under notice from the original supplier, as well as the location of the production matrix.

The second stage consisted of assigning each company a sectorial economic classification, taking as a starting point the United Nations (UN) Central Product Classification System (CPC). The CPC is a classification structure for goods and services based on a set of internationally agreed concepts, definitions, principles and classification rules. It provides a format that allows analysis for decision-making and the formulation of public policies (UN, 2021). In this case version 2.1 of the CPC was used.

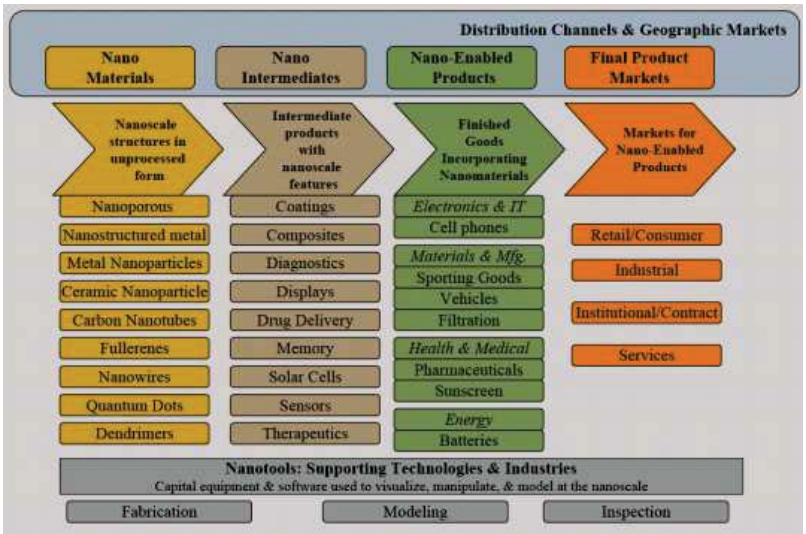
Due to the great diversity of products we found, equivalence was established between the CPC and the fourth revision of the International Standard Industrial Classification System for all economic activities (ISIC 4). This classification, also from the UN, offers a set of categories of productive activities that are used to compile statistics on economic activities (UN, 2002). ISIC 4 seeks to present this set of categories so that agents (in this case, companies) can be classified according to the economic activity they carry out.

When looking for companies, the first thing we look up on is the nanoenabled product, but with more than a hundred different products, the economic classification becomes complex. When we applied the concordance between CPC-ISIC 4 (UN, 2008, p. 45), we were able to establish an equivalence of these products with the ISIC divisions, helping a simplified economic classification in just over twenty sectors.

After this classification was obtained, we placed the companies into an adapted production chain (Frederick, 2009) (Figure 1), in order to determine if they produce raw nanomaterials, nanoenabled devices, final nanoenabled goods or even nanotools for measurement or manipulation of nanoparticles.

Figure 1

General Nanotechnology Value Chain



Source: taken and adapted from Frederick, (2009)[1]

Figure 1 shows each stage of the chain with examples of nanomaterials, nanoparticles, nano intermediates, final products and nanotools. The location of each company in a production chain such as the one exemplified makes it possible to understand the ties it has backwards and forwards, since it will depend on other producers.

RESULTS

We found 164 companies that fabricate and/or sell nanotechnology products in México. When the CPC-ISIC 4 concordance was applied, we found that 50 companies are in ISIC 4 division 20: "Chemical manufacturing and chemical products". The second sector with the most companies is ISIC 4 division 47: "Retail trade, except motor vehicles and motorcycles", with 15 companies. This shows the high concentration in the production of chemicals and raw materials that will be incorporated into other production chains. Third place is ISIC 4 division 10: "Manufacture of food products", with 14 companies. The remaining 85 companies are located in divisions like "Wholesale trade, except of motor vehicles and motorcycles"; "Manufacture of electrical material"; "Pharmaceutical, medicinal chemical and botanical manufacturing" and others that we will not list here.

About the geographical location, The Latin American Nanotechnology and Society Network (ReLANS) elaborated an interactive map of these companies, where the company´s geographical location, its economic sectorial classification and the main fabricated product -in case of severals- was stamped (Figure 2). The majority of the companies are concentrated in

[1] For purposes of this research, we excluded from the model what Frederick calls "external environment"(government, universities, NGO`s, consumers and other agents that participate externally on the chain).

two states. The first one is Nuevo León with 54 companies, Mexico City runs in second place with 43 firms. The remaining 67 companies are distributed in 19 states, mainly in the northern border and central regions. To access the precise location and a more detailed visualization, we recommend to consult the interactive map on the ReLANS website.[2]

Figure 2

Geographical distribution of nanotechnology companies

Source: own elaboration

Regarding the production chain (Figure 3), there are 22 companies that manufacture nanomaterials; 39 companies manufacture nanointermediates and devices; 94 companies participate in the manufacture and commercialization of final nanoenabled products (79 in the manufacture and 15 in the commercialization).

Figure 3

Nanotechnology production chain in Mexico

22 companies	39 companies	79 companies	15 companies
	Nanotools (9 companies)		

Source: own elaboration

[2] At: https://relans.org/empresas-nano-en-mexico/

There are also 9 companies that manufacture nanotools for the measurement and handling of nanomaterials. Regarding the origin of production, 83% (137 companies) have national production, while 17% (27 companies) import and retail their products through the internet, in independent commercial premises or shopping malls.

CONCLUSIONS AND DISCUSSION

A considerable part of the developing countries have ventured into the nanotechnological wave without a public agenda that determines key sectors, specific financing or inventories to know the number of nanotechnological companies, products and capacities.

Mexico`s National Council for Science and Technology (CONACYT), through its Project Frontier Science 304320 (ReLANS, 2019), carried out an inventory with information from different sources, which allowed to know the geographic location, product, local production or retail, and economic sector of the companies that manufacture or sell nanotechnologies in Mexico (Arteaga Figueroa, 2021).

The methodology used in this research can be replicated in other countries considering, of course, the heterogeneity of the information sources available in each place, but it can be generalized when the CPC-ISIC 4 concordance method is applied. Following the presentation in International Congresses of this methodology and its outcome is a call for other researchears willing to interact in an expanded scope.

According to this inventory, the majority of the companies are located in the most industrilized metropolitan areas of the country, mainly Nuevo León and Mexico City. Almost one third of the total is dedicated to the manufacture of chemical products.

Promoting a mandatory registration of companies that use nanomaterials or sell nanoenabled products is key for the creation and implementation of a public policy on nanotechnologies.

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