# Measuring Greening of Industry 4.0 in Mexico: Imbalance in Economic Activity and City Size

## *Medición de la ecologización de la industria 4.0 en México: Desequilibrio en la actividad económica y el tamaño de la ciudad.*

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**Abstract**

The article clarifies the way in which the Green Industry Agenda is incorporated in the industrial sector across the cities of Mexico in 2014. It seeks to explain whether Knowledge Intensive Activities (KIA) are also intensive in the exercise of environmental practices with respect to other industries and if KIA located in the largest cities are the most innovative in environmental terms. The results indicate that KIA located in the largest cities of the country are not the most environmentally concerned but that the urban hierarchy has an important weight in the incorporation of the Green Industrial Agenda.

**Keywords:** Green Industry Agenda, Industry 4.0, Knowledge Intensive Activities, Urban System.

**Jel Codes:** O33, Q01, R11.

**Resumen**

El artículo aclara la forma en que se incorpora la Agenda de la Industria Verde en el sector industrial de las ciudades de México en 2014. Se busca explicar si las Actividades Intensivas en Conocimiento (KIA) también son intensivas en

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el ejercicio de prácticas ambientales con respecto a otras industrias y si los KIA ubicados en las ciudades más grandes son las más innovadoras en términos ambientales. Los resultados indican que las KIA ubicadas en las ciudades más grandes del país no son las más preocupadas ambientalmente, sin embargo, la jerarquía urbana tiene un peso importante en la incorporación de la Agenda Industrial Verde.

**Palabras clave:** Agenda de Industria Verde, Industria 4.0, Actividades Intensivas en Conocimiento, Sistema Urbano.

## 1. Introduction

The Fourth Industrial Revolution has meant "ubiquitous, mobile supercomputing; intelligent robots; self-driving cars; neuro-technological brain enhancements; genetic editing, among drastic innovative life and economic, social, cultural, and environmental changes. The evidence of dramatic change is all around us and it's happening at exponential speed" (Schwab, 2017). However, the adoption of these technologies will not be neutral and homogeneous in productive, spatial and, as we try to show in this work, environmental terms. The change will mean the creation of new industries, and the reconfiguration of existing ones, to be part of the so-called industries of the future (Ross, 2016) or industries 4.0 (Schwab, 2017). Several authors have pointed out that the result of the above has been, especially in developed countries, the progressive bifurcation of economic activity into two subcategories: 1) 'knowledge-intensive activities' (KIA) whose jobs require high content of knowledge and creativity, which they receive high salaries and in which the adoption and generation of 4.0 technologies is more feasible; and 2) 'not knowledge intensive activities' (NKIA), a large group of jobs that do not require great skills or knowledge with an increasing possibility of being replaced by the imminent development of intelligence and dexterity artificial. In parallel, there is a reduction in manual and medium-skill activities (MKIA). Geographically, the large cities tend to concentrate the most innovative activities with high levels of productivity and salaries, while in the medium and small cities generally are activities that develop more conventional processes. Over time, we would expect a filtering process top-down in the city system or a center-periphery decentralization.

In this framework we ask if the previous economic-spatial characteristics also occurs in terms of the adoption of the Green Industry Platform, an approach to industrial production and development in which the objective is the mainstreaming of social and environmental considerations in the operations of enterprises through the more efficient use of energy and raw materials, innovative practices, and applications of new green technologies (UNIDO, 2011). As a hypothesis, we would suppose that the KIA, located in the large cities would have higher levels in support of the Green Industry agenda compared to the NKIA and MKIA, whose economic, spatial, and environmental logic would be the opposite.

The objective of this article is to evaluate the particularities of the Green Industry Initiative of the KIA and NKIA across the cities of Mexico in 2014. We selected Mexico for two reasons. First, to know the progress of this polarization in a developing country that has multiple international environmental commitments. Second, because it is important to document the green industrial practices of this type of leading industries as well as to investigate if a green industrial policy is being built. Methodologically, economic activity is classified according to its intensity of knowledge within the Industrial Classification System of North America (NAICS). We use, as a source of information, the microdata of Economic Censuses to know the practices and the operations that can be compared between urban units of different sizes. Finally, the proposal seeks to contribute theoretical and empirical elements to answer what evolving roles of green innovation and services processes are. The article is structured in five sections, in addition to the present introduction. The first discuss conceptually some of the possible positive and negative effects, the uneven distribution and the environmental implications of the Industrial Revolution 4.0. The second exposes the methodology that we used to elaborate this work. The third analyses the empirical information on the environmental practices of the KIA and other industries through the Urban System of Mexico. The fourth develops some final reflections that seek to generate concerns for future research on the subject. Finally, the five section presents the references of the revised bibliography to elaborate this work.

## 2. Conceptual Framework: Knowledge, Industry 4.0, Cities and Environment

### 2.1. Industry 4.0 y/o Knowledge Intensive Activities

The current technological development is -and will continue- generating an accelerated and profound change in our industry, society and environment. Technologies ranging from robotics to artificial intelligence (AI), through the Internet of Things (IoT), 3D printers, blockchain technology, augmented reality, neural networks, machine learning (deep learning), quantum computing and Big Data they are just the tip of the iceberg of technological developments that have become increasingly ubiquitous, accessible at their cost and increased their interconnection and accelerated innovation speed (Ford, 2015; Brynjolfsson & McAfee, 2016). This new digital revolution holds the promise of increased flexibility in the production, mass customization, increased speed, better quality and improved productivity and environment (Davies, 2015; Stock & Seliger, 2016).

The intensive application of this technology opens an immense range of industrial application, but whose effect we could group in two spheres. The first is 'inside' the industry. In this sphere is hoped that these technologies will transform the organization of the production systems (suppliers, the plant, distributors, even the product itself), make productive systems more flexible (accelerate the response to changes in the markets), increase productivity, improve product quality, reduce environmental impacts of resource use, and modify economic and spatial organization of value chains (Brettel et al., 2014; Güven et al., 2017; Sundblad, 2018). The second sphere is 'among' industries. The merger of the mentioned technologies and their interaction through the physical, digital and biotechnology domains is allowing the creation of new industries, the improvement of the productive processes of many industries and the obsolescence of others (Robertson, 2017). Among the new industries we find examples such as: robotics, advanced life sciences, the codification of money, cybersecurity, Big Data, the development of online sales services such as car services, medical examinations from home, ordering food directly sent from the store to the refrigerator (Ross, 2016; Roblek et al. 2016).

The effects of these transformations have led to suggest that we are currently facing "the industries of the Future" (Ross, 2016), "a new era in the industry" (Güven et al., 2017) or "The Fourth Industrial Revolution" (Schwab, 2017). These approaches coincide in pointing out that the effects of the current digital technological development extend throughout the industrial spectrum, from agriculture to services (Schwab, 2017; Krasodomskyte, 2016; Ford, 2015, De Clercq et al., 2018; Brettel et al., 2014; Davies, 2015).

While the previous scenario is a point of convergence in a broad set of literature, we consider that it only shows one side of reality, the positive effect of industries 4.0. The other side is presented by David Autor and others who suggest that technological development will result in a deep polarization of employment. This process will consist in the reduction of the jobs of average skills -manufactures, transport, trade- due to the process of robotization and automation and the configuration two sub-groups of white collar jobs: 1) jobs that require high skills content (high-skill), knowledge and creativity and 2) a large group of jobs that do not require great skills or knowledge (low-skill) (Autor et al., 2006; Manning, 2004; Goos et al., 2008; Fehr et al., 2008; Spitz-Oener, 2006; Sach & Kotlikoff, 2012; Lindley & Machine, 2013; Florida & Mellander, 2014).

The analytical position suggested by the latter authors, which recognizes the side effects of the current technological development, has several attributes that we consider lead to a wider reading of the processes that will bring the new wave technology within our societies. First, this position allows escaping the determinism or technological triumphalism to pass to recognize the central function of ' knowledge ' in the development, adoption, and diffusion of technology (Robertson, 2017; Jones & Romer, 2010). Second, to understand that the current technological development will have differentiated effects according to the characteristics of each industry. Third, to assess the trend that the territories (national, regional, and urban) follow in this transformation.

Based on the previous ideas, in this work we suggest distinguishing the economic activity according to its 'intensity'[5] and type of knowledge defining three groups of activity. The first group defined as 'Knowledge Intensive Activities ' (KIA), which is characterized by industries employing individuals with high levels of knowledge, creativity and talent (Moretti, 2013). This last quality allows them to develop a central function in the processes of generation of innovations (technological), discoveries (scientists) and creations (artistic-cultural). In other words, these are activities that are the engine of the so-called "Fourth Industrial Revolution" or those responsible for the development of technologies 4.0.

The second group, 'Non-Knowledge Intensive Activities' (NKIA), are activities in which the development of intelligence and artificial skills will have their first disruptive effects by allowing their automation, which would derive in their greatest precarization and eventual substitution (Autor & Salomons, 2017; Manning, 2004; Bowles, 2014). In other words, the "hidden" side of the Fourth Industrial Revolution. These two subcategories will be the conceptual axis for spatial analysis and environmental practices (green) of the two extremes of this classification. The third group, 'Middle Knowledge Intensive Activities' (MKIA) is a broad array of pursuits of intermediate levels of sophistication in areas including distribution, transportation and manufacture (Roberson, 2017: 19).

## 2.2. Spatial dimension of the process

Despite the multiple possibilities offered by technology to adopt new locations (Güven et al., 2017), the literature agrees that the previous transformations and their application will take place primarily in the cities (Glaeser, 2011; Ross, 2016; Florida, 2005). Cities are incubators of growth because they produce positive externalities, or spillover effects for industries and individuals. For industries, on the one hand, the cities allow ideas, labor, and capital to flow rapidly and efficiently. Talent can be more effectively coordinated, and markets -local and/or global- can be more specialized and the size of the markets needed to sustain their activity (Storper & Christoperson, 1987). Individuals, on the other hand, find spatial proximity to set face-to-face contacts necessary for the exchange of knowledge (Storper & Venales, 2004), The concentration and diversity of amenities according to their lifestyles and consumption -openness, diversity, tolerance and internationality- (Glaeser, 2011; Florida, 2005), and the breadth of markets where they can be inserted at work (Hemert et al., 2009: 48-49).

While the previous approach is encouraging for cities and emphasizes its importance as spaces of creation, it is also true that these changes will not be

5 The 'intensity of knowledge' of an industry refers to the characteristics of its employees in terms of their human capital, talent, and skills that they apply and develop in their work activity.

homogeneous through the urban-global or international system. Industries 4.0 will generate changes in business models that reinforce innovation-based competition -although it is happening now- (Güven et al., 2017; Shearmur, 2012). In such a way that "could have greatly disadvantage for less technologically sophisticated countries and cities" (IDCR, 2018; Beier et al., 2017). So, are all cities a milieu suitable for generating innovations? (Camagni, 1991; Shearmur, 2012) and Are these same cities will have the best environmental conditions because they develop industries 'knowledge intensive' or oriented to the adoption of Technologies 4.0?

Theoretically, there are two hypothesizes that seek to answer these last questions. The first suggests that the development of technologically more advanced and innovative industries occurs first in the big cities because they find the economies of agglomeration- urbanization which require for develop their economic activities (Duranton & Puga, 2001). It is from those cities that a process of "down filtering" o "cath-up" to smaller cities-although this process is not always linear- (Shearmur & Doloreux, 2008; Robertson, 2017). The idea behind this approach is that there will be a reinforcement of territorial inequalities, suggesting that those initially skilled cities have become more skilled over time (Berry & Glaeser, 2005; Moretti, 2012).

The alternative hypothesis is that the same technological development will allow other spaces to gain access to the benefits of the Fourth Industrial Revolution. The central role of the development of communication and transport systems has been emphasized - for example, through augmented reality- that will allow the delocalization of multiple processes or the development of processes across the distance (Ross, 2016: 199; Shearmur, 2012). The possibility has been raised that the development of the 4.0 industries and their positive and negative effects do not follow the urban hierarchy (Malecki, 2010); in other words, technological development would not necessarily be related to the size of the cities but with the function that develops that city within the urban system.

### 2.3. Green Industrial Agenda in KIA

With the Fourth Industrial Revolution, the industrial organization is in transition. The challenges of the increase in digitalization and 'intelligentization' (Zhou, 2013) of production processes, which will lead to a high degree of automation and autonomy, suggest that Industry 4.0 will not only rethink the concept of competitiveness but will also be based on sustainability.

The invitation to the industry for the incorporation of sustainability was given by the mandate of the United Nations Industrial Development Organization (UNIDO), called The Green Industry Initiative[6] described above. The Initiative was announced in 2009 during the International Conference

6 That shares theoretical roots with the concept of Green Economy.

on Green Industry in Asia in Manila, Philippines. Building on the outcome of this Conference and the follow-up conference in Tokyo, Japan in November 2011, UNIDO is now proposing to implement the Initiative through the launch of a global high-level multi-stakeholder action partnership, to be known as the Green Industry Platform. The Platform was formally launched on 2012 UN Conference on Sustainable Development, held in Rio de Janeiro, Brazil.

The Green Industry involves a two-pronged strategy: 1) greening of existing industry: its operations, processes and products by using resources more efficiently; transforming industrial energy systems towards greater sustainability by expanding renewable energy sources; phasing out toxic substances; and improving occupational health and safety at the industrial level; and, 2) creating green industry by establish and expand (new) green industries that deliver environmental goods and services (UNIDO, 2011, 2017). This paper focuses on the first strategy of the Green Industry.

On the other hand, while Industry 4.0 does not explicitly refer to the ecological sustainability of production systems as a major objective of its program, it is possible to assume that, due to the high levels of knowledge, creativity and talent, characteristic of the Fourth Revolution, these systems first express environmental concerns about the impacts of their decisions. In this sense, the production technology and operations research community has recently addressed ecological impact and sustainability (Geels et al, 2015).

That is, because the Industry 4.0 are companies in which the skills to assess information, qualitatively locate, make decisions and interact with the environment more effectively, will be the best positioned to implement sustainability in their processes and therefore will be more competitive in the long term. Thus, the adoption of the Green Industry concept could be for Industry 4.0 an important practical pathway towards achieving sustainable development.

In the search for the Green Industry, changes and challenges arise for all the companies in the world. At the Global level, there are adopted patterns of low carbon, water and material use in order to decrease the environmental footprint of a value chain. However, these patters vary from country to country and the pressures for companies located in developed countries and for those located in developing countries are greater.

How do KIA in developing countries to become greener and shrink their environmental footprint?

Although it has not been documented in a specific way how KIA become greening in developing countries. There has been pointed out that the first strategy that is followed to implement the Green Industry concept is to decouple production from the consumption of resources (UNIDO, 2010). The intention is to maximize the efficiency of resources and implement clean production through the transition to renewable energy sources, the redesign

of products and the development of more efficient production technologies. However, the most recurrent way in which companies in developing countries address this aspect is by the recycling of waste they generate. The second strategy is reducing industry's impacts on the local environment (UNIDO, 2010) through the minimization of waste and the pollution it produces or neutralizing the environmental impacts it generates. However, this dimension is limited to the local development of pollution-control infrastructure -as wastewater treatment plants or recycling centres-. Companies in developing countries experience a tension. On the one hand, global trends in the industry put pressure on them to be more efficient and sustainable if they want to remain in the market. On the other hand, its transformation is restricted to a series of structural deficiencies whose lag is not attributable to these companies.
Based on the previous theoretical review we ask, if in Mexico, a developing country, are KIA industries intensive in the exercise of different environmental practices with respect to other groups of activities? what kind of practice is most recurrent? are the KIA located in the largest cities in the country the most innovative in environmental terms? are there significant differences between KIA and NKIA located in different sized cities in the country? The following section presents the methodology that is followed to explore the research question and to test the hypothesis.

## 3. Methodology and Data

### 3.1 Definition of KIA

Try to resolve the previous questions require understand the economy of different way (Graizbord & Santiago, 2019). One option is recognizing the function of industrial activity in the production of knowledge and innovation, this is according to the knowledge-intensity (Shearmur & Doloreux, 2008). Thus, we identify three sub-groups. The first is the KIA, which are defined as services industries that developing intellectual operation with creative and high skills workers, and which we suppose environmental practice are developed more intensively. The second group, NKIA (Not Knowledge Intensive Services), is a group of services industries that are oriented to resolve common problems that do not require high creativity, knowledge, or skills (Shearmur & Doloreux, 2008; Florida & Mellander, 2014) and whose environmental practices are not commons. The third is MKIA, activities with intermediate levels of sophistication in areas including distribution, transportation, manufacture and construction.

Santiago (2016), based on the standard classification of economic activities NAICS classification (Norte America Industrial Classification, NAIC-2007), has identified for Mexico a very detailed set of service disaggregated sectors (five digits) that use knowledge intensively in production and consumption as follows (Table 1).

**Table 1**
KIA, NKIA and MKIA sectors definition

| KIA | NAIC |
|---|---|
| University education | 61131 |
| Specialized medicine | 62231 |
| Research and development | 54171, 54172 |
| High tech engineering | 54133, 54136, 54151, 54169 |
| Administration services | 54121, 54161, 55111 |
| Legal services | 54111, 54112, 54119 |
| Financial services | 52111, 52221, 52222, 52311, 52391, 52399 |
| Technical education | 61121, 61141, 61143, 61163 |
| Non-specialized medicine | 62111, 62121, 62131, 62132, 62133, 62134, 62139, 62211, 62221 |
| Diverse services | 54162, 54193, 54194, 54199, 61171 |
| Massive communication media | 51111, 51112, 51113, 51511, 51512, 51521, 51913, 54181, 54182, 54184, 54186, 54191, 54192, 61162, 71121, 71131, 71132, 71141 |
| Cultural activities | 51211, 51219, 51221, 51222, 51223, 51224, 61161, 71111, 71112, 71113, 71119, 71151, 71211 |
| Desing | 54131, 54132, 54141, 54142, 54143, 54149 |
| | |
| **MKIA** | |
| Middle Knowledge Intensive Activities | The rest of the sub-branches of the sectors: 31, 32, 33, |
| **NKIA** | |
| Non Knowledge Intensive Activities | The rest of the sub-branches of the sectors: 51, 52, 53, 55, 56, 61, 62, 71, 72 and 81 |

Source: Santiago (2016: 133-135).

## 3.2. Urban System Classification

The analysis of the location and spatial distribution of the environmental practices developed by the KIS and NKIS in Mexico was carried out through the 384 cities of the national urban system. The definition used to define the cities that make up the national urban system corresponds to those human settlements that have a population of more than 15 000 inhabitants (Sedesol, Conapo & Segob, 2012).

To know if the environmental practices of these groups of activities are positively related to the urban hierarchy or if the same technological development has reduced the weight of said hierarchy as a determinant in the development of such practices, the 384 cities were classified according to two analytical axes: i) their size and ii) their location. From the first, five classes are distinguished, as presented in Table 2. With the second axis, cities of similar size were classified according to their location: closer to a national and regional metropolis (central) or more distant (peripheral) (Table 2).

**Table 2**

Cities: Classification by size

| Size | Range (millions) | n | 2010 | | 2018 | |
|---|---|---|---|---|---|---|
| | | | Absolut | % | Absolut | % |
| México | | | 112.34 | 100 | 126.01 | 100 |
| Total | | 384 | 91.91 | 81.82 | 92.10 | 73.09 |
| I | 2.00 y más | 4 | 34.74 | 30.93 | 34.74 | 27.57 |
| II | 1.00 y 1.99 | 7 | 11.57 | 10.30 | 11.57 | 9.19 |
| III | 0.50 y 0.99 | 22 | 19.29 | 17.17 | 19.29 | 15.31 |
| IV | 0.25 y 0.49 | 22 | 9.09 | 8.09 | 9.09 | 7.21 |
| V | 0.10 y 0.24 | 40 | 7.60 | 6.76 | 7.60 | 6.03 |
| VI | 0.05 y 0.09 | 40 | 2.99 | 2.66 | 2.99 | 2.37 |
| VII | 0.015 y 0.05 | 249 | 6.63 | 5.90 | 6.82 | 5.41 |

Source: The population information of 2010 from Census of Population and Housing Units, INEGI, (https://en.www.inegi.org.mx/progr amas/ccpv/2010/); 2018 from National Urban System definition (http://www.conapo.gob.mx/conapo/documentos/sistema-urbano-nacional-2018)

### 3.3. Data and Indicators

To analyze the environmental practices of KIS and NKIS we use the information of the environmental module provided by the Economic Census of 2014 produced by INEGI. Three types of environmental practices are analyzed: 1) environmental care, 2) waste management and 3) energy consumption.

To shape these three aspects, six questions were used by the INEGI (Economic Census, 2014 -Methodology-). The first aspect was quantified with the question: did this economic unit comply with any regulations on the environment?[7] Key: O611A) and did this economic unit have staff dedicated to environmental protection activities or natural resources? (Key: O615A). The second from the question and options: did this establishment perform any of the following activities to protect the environment or natural resources? management, transport, and confinement of hazardous wastes (urban solids) (key: O612_4A); management, transport and confinement of hazardous was-

7 (INEGI, Economic Census: http://www.inegi.org.mx/est/contenidos/Proyectos/ce/ce2014/doc/glosario/glosa_ce2014.pdf).

tes (key: O612_5A); did this economic unit separate the waste or waste it generated? (key: O617A). Finally, the third aspect was evaluated from the question: did this establishment perform any of the following activities to protect the environment or natural resources? Reduce energy consumption or use alternative energy -solar, wind energy, other- (key: O612_1A).

The answer of these questions allows to quantify the number of establishments or economic units (EU) that carry out such practices or comply with a specific environmental standard. EU is defined as the place or entity where the economic activities are carried out, said entity or unit can be a factory, office, bank, exchange house, school, hospital, repair shop, transportation company, government offices or other establishments, including a housing space or a worker on their own without establishment. The information of each sub-branch that make up the KIS, NKIS and other sectors was processed directly in the Microdata Lab of INEGI in July 2018, whose access was possible through the project LM-727: "The industries of the future in Mexico: Which cities meet the best conditions for their development?".

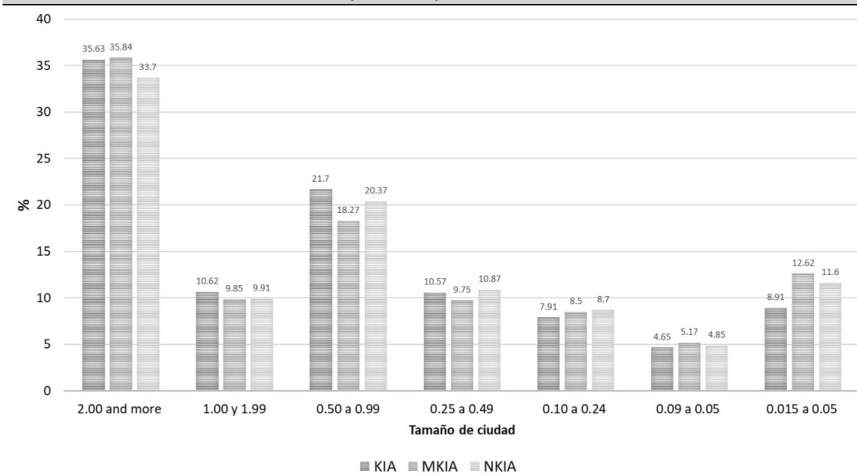
## 4. Results: Green Industrial Platform of KIA Through Mexican Urban System, 2014

### 4.1. Basic Data

In Mexico, 4.41 million 'economic units' (eu) were registered in 2014. The national urban system concentrated approximately 75.05% (3.31 million), of which 35.23% were in the four largest cities in the country (Mexico City, Guadalajara, Monterrey, and Puebla) and the rest was distributed among 380 cities. This characteristic defines these four cities as the main node of economic activity in the country. KIA were just over 244 thousand eu in the urban system of Mexico. The spatial distribution of these economic activities is closely associated with the size of the cities since their levels of concentration decrease systematically as the size of the cities decreases. However, cities with 2 million and more inhabitants concentrated 35.63% of the KIA eu (Figure 1).

On the other hand, the activities classified as "Non-Knowledge Intensive Activities' (NKIA) and 'Middle Knowledge Intensive Activities' (MKIA) --middle-skills, that group together manufacturing, transport and commerce- are the predominant ones in the economic structure of the urban system. Within the economic structure of cities, the two groups of activities represented on average 20 and 60%, respectively (Figure 2). These results indicate the current productive orientation of the cities in Mexico is not toward activities whose base is a specialized knowledge. This characteristic opens questions about the possibilities of Mexico and its cities being incorporated into the current digital technological revolution. In the following section, the characteristics of the environmental practices of this small group of activities are analyzed.

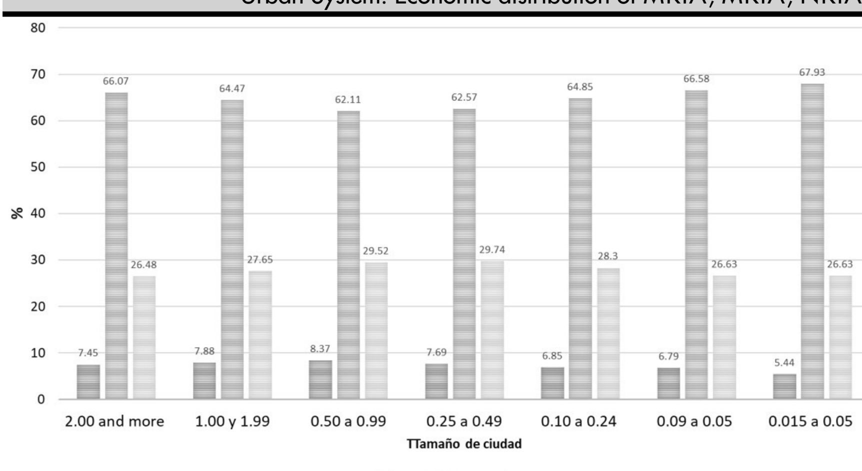
**Figure 1.**
Urban System: Spatial distribution of MKIA, MKIA, NKIA




Note: KIA= Knowledge Intensive Activities: MKIS=Middle Knowledge Intensive Activities; NKIA=Not Knowledge Intensive Activities.

Source: Economic Census, Microdata Lab, INEGI. Project: LM 727-The industries of the future in Mexico: What cities have the best condition for the 'knowledge intensive services' development?

**Figure 2.**
Urban System: Economic distribution of MKIA, MKIA, NKIA




Note: KIA= Knowledge Intensive Activities: MKIS=Middle Knowledge Intensive Activities; NKIA=Not Knowledge Intensive Activities.

Source: Economic Census, Microdata Lab, INEGI. Project: LM 727-The industries of the future in Mexico: What cities have the best condition for the 'knowledge intensive services' development?

**4.2. Green Industrial Platform of KIA**

In general terms, the proportion of urban areas that develop a practice related to an environmental agenda in Mexico is reduced. Among the eu located in the urban system, only 11.74% comply with an environmental standard, 1,842% have personnel dedicated exclusively to environmental tasks, only 7.55% of them carry out waste separation, although the latter does not necessarily mean that those residues have some treatment or adequate final disposal - and on average only 1.5% perform some activity aimed at protecting the environment through the management of hazardous and non-hazardous waste (Table 3).

The eu of the KIA are not characterized by carrying out any environmental practice analyzed in this work. Its main environmental practice is the certification of its activity through the fulfillment of some environmental norm and the separation of waste. KIAS that meet these characteristics represent 5.14% and 3.36%, respectively, of the total urban economic units in the country. The other environmental practices analyzed (having personnel dedicated to the care of the environment, the handling of hazardous and non-hazardous waste, and the use of technology to reduce their energy consumption) are carried out by a much smaller number of eu of KIA. The activities oriented to the production of scientific knowledge (KIA-analytic) are those that have the highest number of eu with environmental certification and that carry out waste separation exercises. The other two sets of activities (KIA-synthetic and symbolic) have a minimal participation in environmental practices (Table 3).

On the other hand, contrary to the expected, the NKIA and the MKIA are activities that have a greater proportion of eu that carry out or develop some environmental practice in comparison with the KIA. The MKIA stand out. In this group of activities 13.75% of their eu meet an environmental standard, 8.79% make separation and 2.11% use some technology to develop their economic activity from alternative sources of energy. In the case of the NKIS, their main practices are to meet requirements with some environmental norm (8.78%) and carry out the separation of waste (5.77%), although undoubtedly it is proportions below the national urban average (Table 3).

The previous results indicate that the greater proportion of the KIA located in the urban system of Mexico are not within a green platform. This result can be interpreted from different hypotheses: the results could be showing the same nature of the economic activity that the KIA develop (that is, activities whose production process is the generation of knowledge and innovations through intelligent systems of high technology) or indicating that it is necessary to take different forms and characteristics to qualify the activities oriented to protect the environment within the economic censuses of the country. These aspects are reflected in the final section of the chapter. For the time being, the following section addresses the spatial dimension of KIA environmental practices.

**Table 3**
Urban System: Green Industrial Platform of KIA, MKIA and NKIA, 2014 (Economic Units)

| | Total | Environmental Care | | Waste Management | | | Energy Consumption |
|---|---|---|---|---|---|---|---|
| | | Environmental certification | Personal | Not Hazardous | Hazardous | Waste sorting | |
| **Absolut** | | | | | | | |
| *Total* | *3 312 675* | *388 810* | *46 933* | *41 451* | *47 332* | *250 241* | *47 145* |
| KIA | 244 006 | 12 537 | 134 | 91 | 88 | 8 209 | 88 |
| Analytic | 6 982 | 3 148 | 0 | 13 | 12 | 1 963 | 13 |
| Synthetic | 196 178 | 6 368 | 134 | 70 | 68 | 4 364 | 68 |
| Symbolic | 40 846 | 3 021 | 0 | 8 | 8 | 1 882 | 7 |
| MKIA | 2 151 481 | 295 735 | 23 880 | 39 688 | 45 420 | 189 098 | 45 464 |
| NKIA | 917 188 | 80 538 | 22 919 | 1 672 | 1 824 | 52 934 | 1 593 |
| **Horizontal Percentages (%)** | | | | | | | |
| *Total* | *100.00* | *11.74* | *1.42* | *1.25* | *1.43* | *7.55* | *1.42* |
| KIA | 100.00 | 5.14 | 0.05 | 0.04 | 0.04 | 3.36 | 0.04 |
| Analytic | 100.00 | 45.09 | 0.00 | 0.19 | 0.17 | 28.12 | 0.19 |
| Synthetic | 100.00 | 3.25 | 0.07 | 0.04 | 0.03 | 2.22 | 0.03 |
| Symbolic | 100.00 | 7.40 | 0.00 | 0.02 | 0.02 | 4.61 | 0.02 |
| MKIA | 100.00 | 13.75 | 1.11 | 1.84 | 2.11 | 8.79 | 2.11 |
| NKIA | 100.00 | 8.78 | 2.50 | 0.18 | 0.20 | 5.77 | 0.17 |
| **Vertical Percentages (%)** | | | | | | | |
| *Total* | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| KIA | 7.37 | 3.22 | 0.29 | 0.22 | 0.19 | 3.28 | 0.19 |
| Analytic | 0.21 | 0.81 | 0.00 | 0.03 | 0.03 | 0.78 | 0.03 |
| Synthetic | 5.92 | 1.64 | 0.29 | 0.17 | 0.14 | 1.74 | 0.14 |
| Symbolic | 1.23 | 0.78 | 0.00 | 0.02 | 0.02 | 0.75 | 0.01 |
| MKIA | 64.95 | 76.06 | 50.88 | 95.75 | 95.96 | 75.57 | 96.43 |
| NKIA | 27.69 | 20.71 | 48.83 | 4.03 | 3.85 | 21.15 | 3.38 |

Note: KIA= Knowledge Intensive Activities: MKIS=Middle Knowledge Intensive Activities; NKIA=Not Knowledge Intensive Activities.

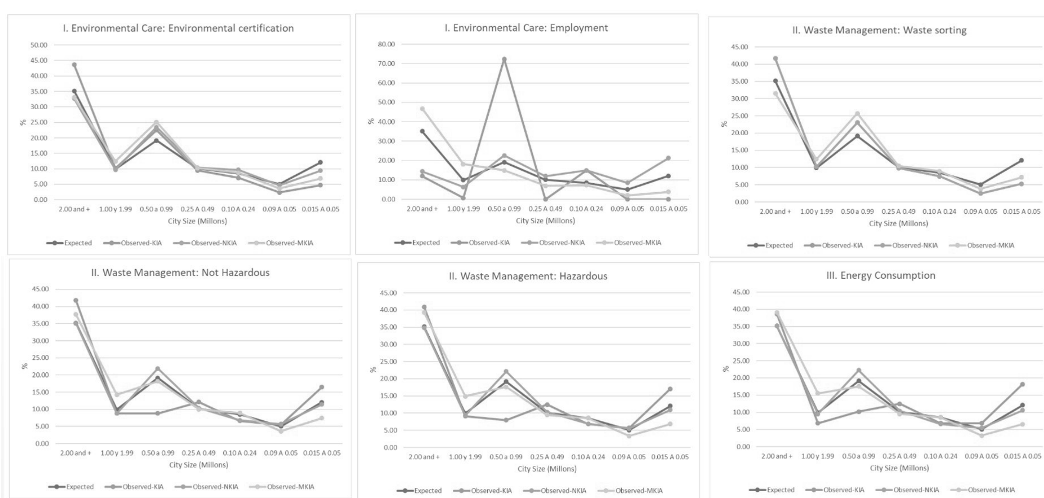
Source: Economic Census, Microdata Lab, INEGI. Project: LM 727-The industries of the future in Mexico: What cities have the best condition for the 'knowledge intensive services' development?

## 4.3. Spatial Logic of Green Industrial Platform of KIA

Although the proportion of KIA that could be registered in a green platform in the urban system is small, the results indicate that the largest proportion of those located in the large cities of Mexico. In percentage terms, these cities are concentrated between 30 and 40% of the KIA's that meet the requirements of an environmental standard, which has some handling of non-hazardous and hazardous waste, and which use technology aimed at taking advantage of alternative energies. The only variable that is not associated with the previous spatial feature is those that have personnel dedicated exclusively to environmental protection activities, since these are concentrated mainly in the intermediate cities (72.39%). A possible explanation of this last characteristic is than the economic orientation of these cities is manufacture, which demand more personal to attend the environmental normativity (Figure 3).

However, one feature to highlight is that the same pattern occurs in the case of the NKIA and MKIA. The greater proportion of the eu of NKIA and MKIA that develop some environmental practices are in the big cities of the country and this proportion decreases systematically as it descends in the urban hierarchy (Figure 3).

**Figure 3.**
Relation Between Expected and Observed Spatial Distribution of Green Platform of KIA, MKIA and NKIA, 2014. (Chi-square test)




Note: KIA= Knowledge Intensive Activities: MKIS=Middle Knowledge Intensive Activities; NKIA=Not Knowledge Intensive Activities.

Source: Economic Census, Microdata Lab, INEGI. Project: LM 727-The industries of the future in Mexico: What cities have the best condition for the 'knowledge intensive services' development?

Despite the high concentration of the select group of KIA-greens in large cities, their spatial distribution is statistically consistent with the average distribution of economic units across the urban hierarchy. The proportion of KIA that develop some practice oriented to protect the environment decreases systematically as it descends in the hierarchy of the national urban system. This characteristic is relatively consistent in all the environmental characteristics evaluated in this work (Table 4).

The previous results partially confirm the central hypothesis of this work, since although the KIA in the country are not activities that adopt a green agenda in a generalized way, the greater proportion are located in the big cities. However, in parallel, the greater proportion of the NKIA and MKIA adopting green agenda is also located in the large national cities. The latter is a result that was not expected at the beginning of the work and that opens new guidelines for its investigation because it could suppose some effect of the size of the cities or the proximity that those cities offer in the adoption of a green platform among the economic units located in them.

**Table 4.**
Urban system: Spatial distribution of Green Industrial Platform, 2014
(Chi-square test)

| *Chi-square (0.05, 6)* | *12.59* | | |
|---|---|---|---|
| | KIA | MKIA | NKIA |
| *I. Environmental Care* | | | |
| Environmental certification | 8.89 | 5.27 | 1.92 |
| Employment | 203.89 | 20.25 | 28.58 |
| *II. Waste Management* | | | |
| Not Hazardous | 9.43 | 4.36 | 0.98 |
| Hazardous | 10.57 | 6.02 | 0.98 |
| Waste sorting | 7.30 | 5.63 | 2.05 |
| *III. Energy Consumption* | | | |
| Energy | 10.07 | 6.98 | 1.17 |

Note: KIA= Knowledge Intensive Activities: MKIS=Middle Knowledge Intensive Activities; NKIA=Not Knowledge Intensive Activities.

Source: Economic Census, Microdata Lab, INEGI.

## 5. Conclusions

This chapter has shown the inconsistencies of technological triumphalism, which, like the idea of developmentalist model, proposes the filtration or decentralization of the advanced nodes to the peripheral ones. The findings suggest that there is still a marked concentration of eu in the urban system. Within this, the location of the KIA, the companies with the necessary elements to lead the transition to the Revolution 4.0, supports the idea that the location of these companies implies a reinforcement of territorial inequalities and establishes a gap between the territories in relation to its incorporation to the Revolution 4.0 (Corradini et al., 2021; Balland & Boschma, 2021). This condition poses a problem that must be addressed by policy makers. This inequality must be recognized and considered when establishing strategies for the industrial, economic and social development of the country.

On the other hand, the analysis of the way in which the Green Industry Initiative is incorporated in the KIA and NKIA across the cities of Mexico in 2014 shows that the KIAs are not intensive industries in the exercise of different environmental practices with respect to other groups of activities. The results indicate that the KIAs located in the largest cities of the country are not the most innovative in environmental terms, since also the MKIA and the NKIA located there develop environmental practices, a situation that was not considered at the beginning of the investigation. Regarding the type of practices developed, our findings consolidate what has been found by others (UNIDO, 2010), which identify waste management as the mechanism most used by companies in developing countries to implement a clean production system and minimize industries in the local environment.

In this sense, it is possible to affirm that the green industrial policy is being constructed by location rather than by the intensity of the knowledge that is incorporated into the productive process. In this sense, a new dimension of inequality is created, the environmental dimension. In large cities, enterprises with greater willingness to comply the environmental standards, waste management and the use of alternative energy, converge with the infrastructures for environmental management: landfills, recycling plants and water treatment plants. To the detriment of the peripheral urban spaces where companies with less environmental practices and less urban conditions for environmental management are located. On the other hand, another aspect that should be noted in the recent incorporation of the environmental in the Economic Census. As we explained above, it was not possible to make comparisons between censuses; due to the lack of data on environmental variables in records prior to 2014. This situation tells us about the transition in which the industrial sector is in relation to sustainability.

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