Barriers and incentives to eco-innovation in Mexico

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Abstract

Eco-innovation is currently positioned as a topic of the highest political relevance in developed countries. A number of high-level political forums (UNCTAD, UNFCCC, OECD, UNEP, ASEM) have created manifold expectations around the potential of eco-innovation to become the engine to the green economy and a prime solution to global environmental pressures such as resource degradation, biodiversity loss and climate destabilization. In this context, a better understanding on how to remove barriers to eco-innovation is seen as an area of primary concern for research and policy analysis. For the Mexican case, it is difficult to find explicit policies for eco-innovation support, and as far as our research could go, there is insufficient evidence about the specific incentives to perform eco-innovations in the country.

It is against this backdrop that we present exploratory results from an on-going research project with the aim to identify and to analyze existing incentives and barriers to eco-innovation conditioning the up-take and wider diffusion in Mexico. Incentives and barriers can be classified in some categories: institutional, technological, organizational and behavioral, and those produced by the market dynamic. Regarding the incentives, the authors focus on the set of policy programs sponsoring innovation managed by the Mexican Council for Science and Technology (CONACYT) and the Ministry of Economics. On the side of the barriers, our research focuses on institutional and behavioral ones such as legislation, fiscal regime, intellectual property, company perception of environmental pressures and/or economic risks, etc. The effect of market barriers can be perceived both, as incentive or as a barrier. For the Mexican case, we put forward the hypothesis that the perceived effect might of a barrier. This assumption is due to the low level of development of the so-called national system of innovation and the very insipient market formation of the eco-industry.

The empirical exploration of this article follows a twofold strategy: (1) it attempts to identify the types of eco-innovations developed by companies in different sectors; (2) it looks at the perceived effect of incentives and barriers to eco-innovation in Mexico. Availability of data is rather restricted since there is no statistics for this topic in the country. However, the classification of stages (according to the life cycle of innovation) and scope (incremental vs. radical) of eco-innovation are based on information directly taken from different public programs supporting innovation in firms. Descriptive statistics and content analysis of such information will be presented as part of the exploratory results offered by this paper. Future research will offer further insights on determinants and barriers to eco-innovation in Mexico by analyzing data from in-depth interviews and case studies of companies with eco-innovation potential in a specific sector.

1. Introduction

2.

Eco-innovation is a topic currently positioned with the highest political relevance in some developed countries. The Europe 2020 strategy and a number of high-level political forums *(UNCTAD, UNFCCC, OECD, UNEP, ASEM)* have created manifold expectations around the potential of eco-innovation to become the engine to green growth and a prime solution to global environmental pressures such as resource degradation, biodiversity loss and climate destabilization (Montalvo et al., 2011). At the same time, the general understanding of the side effects and required complementarities of the diffusion of eco-innovation as a solution to these environmental issues is still in its infancy (van den Bergh et al., 2011).

A better understanding of government incentives for the removal of barriers to eco-innovation is seen as an area of primary concern for research and policy analysis (Ekins 2010). For the Mexican case, it is difficult to find explicit policies for eco-innovation support and more critically, to date there is insufficient evidence about the specific incentives to eco-innovation diffusion come from policy instruments in the country (c.f. Montalvo 2002, Diaz Lopez 2009).

Here we present exploratory results from an on-going research with the aim to identify and to analyze the existing policy incentives and barriers to eco-innovation conditioning the up-take and wider diffusion in Mexico. The empirical exploration of this article follows a twofold strategy: (1) it attempts to identify the types of eco-innovations developed by companies in different sectors; (2) it looks at the perceived effect of incentives and barriers to eco-innovation in Mexico.

Barriers to eco-innovation can be classified in five categories: institutional, technological, organizational and behavioral, and those produced by the market dynamic. On the side of the barriers, this paper focuses on institutional and behavioral barriers such as legislation, fiscal regime, intellectual property, company perception of environmental pressures and/or economic risks, etc. The effect of market factors can be perceived both, as driver or as a barrier. For the Mexican case, we put forward the hypothesis that the perceived effect might be more of a barrier. This assumption is due to the low level of development of the so-called national system of innovation and the insipient market formation of the eco-industry in this country. Regarding policy incentives, the authors focus on the set of public programs financing innovation by the Mexican Council for Science and Technology (CONACYT) and the Ministry of

Economics, which have been created since the beginning of the new millennium as pointed out by Casalet (2005) and Villavicencio (2009).

Availability of data is rather restricted since there is no statistics for this topic in the country. However, the classification of stages (according to the life cycle of innovation) and scope (incremental vs. radical) of eco-innovation are based on information directly taken from different public programs supporting innovation in firms. Descriptive analysis of such information will be presented as part of the exploratory results offered by this paper.

In section 2, we briefly present a discussion on concepts regarding eco-innovation approach and policy making related to the fields. Then we describe the policy landscape for innovation in Mexico in section 3, followed by the analysis of empirical outcomes concerning eco-innovation we got in the frame of our research (Section 4). The final section will present some conclusions.

2. Defining eco-innovation

Eco-innovations can be broadly defined as those innovations that contribute to the environmental dimension of sustainable development (Rennings, 2000). One of the most accepted definition of eco-innovation was provided by Kemp & Pearson (2008:7), who define it as the "*the production application or exploitation of a good, service, production process, organizational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk*, pollution and the negative *impacts of resources use (including energy use) compared to relevant alternatives."*

The term eco-innovation is often used interchangeable with that of environmental innovation. Nonetheless, based on the results from the Ecodrive project, Ekins (2010b) provides a useful distinction between environmental innovations and eco-innovations, being the latter term associated to significant gains in both economic and environmental performance.

According to this author, "*Innovation (compared to the reference technology R, which defines the current economy-environment trade-off along the curved line) that improves the environment, (environmental innovation) is to the right of the vertical line through R and the curved line. The lighter shaded area shows where improved environmental performance has been accompanied by deteriorating economic performance. Similarly,* *economic innovation is above the horizontal line through R and above the curved line. The lighter shaded area in this case shows where improved economic performance has been accompanied by environmental deterioration. Eco-innovation is the darker shaded area where performance along both axes has improved".* (Ekins, 2010:270). Hence, it is important to keep in mind the subtle yet important differences in relation to differences in the use of both terms.

Kemp (2010: 397) noted that *eco-innovation is a recent concept of which the analytical base is under construction*. To date, there is not sufficient agreement about their intentionality, scope and degree of change, novelty, contribution to environmental sustainability and resource efficiency and effective policy mixes across the innovation cycle (Ekins, 2010, van den Bergh et. al. 2011). One of the accepted characteristics of eco-innovation is the so-called double externality problem, involving an environmental and a knowledge-sharing externality (Rennings, 2000).[1]

Available classifications are technology-oriented, inspired and dully informed by the early taxonomies of environmental technologies elaborated by the OECD (1985) and ACOST (1992). Such categories include: waste management, recycling, waste minimization, clean technology and measurement & monitoring clean products. Newer classifications also include a number of additional categories, such as renewable energy technologies and green system innovation (see Figure 1).

It is important to mention that the different types of eco-innovation follow the OECD (2005) division of product, process, organizational and marketing innovation and often make reference to the incremental and radical nature of innovation (Rennings, 2000, Kemp 2010, Del Rio et al 2010). In the classification, we can observe that there are dimensions of eco-innovation related to a systemic approach, where institutions, regulations and services are involved, while a common product innovation (i.eg. an electronic device, new soap or textile fiber), are more referred to de scope of the product characteristics an its manufacturing process.

[1] Refer to Kemp (2011) for a review of this topic

Figure 1. Classification of eco-innovations of the Measuring Eco-innovation Project (MEI) funded by the European Commission

Box A. MEI classification of eco-innovation

A. **Environmental technologies**
- Pollution control technologies including waste water treatment technologies
- Cleaning (clean-up) technologies that treat pollution released into the environment
- Cleaner process technologies: new manufacturing processes that are less polluting and/or more resource efficient than relevant alternatives
- Waste management equipment
- Environmental monitoring and instrumentation
- Green energy technologies
- Water supply
- Noise and vibration control

B. **Organizational innovation** for the environment:
- Pollution prevention schemes
- Environmental management and auditing systems: formal systems of environmental management involving measurement, reporting and responsibilities for dealing with issues of material use, energy, water and waste. Examples are EMAS and ISO 14001.
- Chain management: cooperation between companies so as to close material loops and to avoid environmental damage across the value chain (from cradle to grave)

C. **Product and service innovation** offering environmental benefits:
- New or environmentally improved products (goods) including eco-houses and buildings
- Green financial products (such as eco-lease or climate mortgages)
- Environmental services: solid and hazardous waste management, water and waste water management, environmental consulting, testing and engineering, other testing and analytical services
- Services that are less pollution and resource intensive (car sharing is an example)

D. **Green system innovations:**
- Alternative systems of production and consumption that are more environmentally benign than existing systems: biological agriculture and a renewables-based energy system are examples

Source: Kemp and Pearson (2008)

In terms of actors involved in the eco-innovation process, besides the distinction between adopters and developers (Ashford, 1993), eco-innovation studies have not sufficiently focused on a differentiated approach to eco-innovators, namely companies developing eco-innovations with commercialization purposes (e.g. eco-industry, clean tech industry), companies developing eco-innovation for in-house use (e.g. process integrated technologies), intermediaries supporting eco-innovation diffusion, and adopters of eco-innovation not developed in-house.

The policy rationale for the support of eco-innovation rests on the assumption that market mechanisms will fail to deliver the expected support for the uptake of eco-innovations (Del Rio et al, 2010). Key to policy support formulation is the identification of barriers to the development and uptake of eco-innovation, a topic briefly introduced below.

2.1 Barriers to eco-innovation

Barriers to eco-innovation can be the result of both market failures and failures at the systemic level (Kemp, 2011). As previously noted, barriers to eco-innovation present a double market failure effect. Market failures are evident when facing the challenge of addressing a negative economic externality such as air pollution. In addition, technological change also faces a public good nature condition that hampers its wider diffusion (Rennings, 2000; Del Rio, et al 2010). Systemic failures arise when different activities in the enabling environment (innovation system) are not conducive for eco-innovation e.g. not sufficient national R&D capacity, not enough graduates in emerging knowledge areas (e.g. green chemistry or carbon trading management).

The literature of eco-innovation distinguishes between internal and external determinants and barriers to perform it (Horbach, 2008). These are also related to supply and demand side of innovation (Horbach et al 2010; Del Rio 2004). Internal barriers can be found in the lack of resources or capabilities for innovation, low absorptive capacity; also resistance to innovation and change, lack of willingness to eco-innovate among some others linked to management and organizational problems. External barriers are often referred to those pertaining to the large context or the innovation system (Edquist 1997; Hadjimanolis 2003), also related to the enabling set of actors, networks and institutions facilitating or hampering innovation in a country, region, sector or around a specific technology (see Coenen and Diaz Lopez 2010 for a review).

Table 1. Market and system failures for eco-innovation

Category	Market failure approach	System failure approach
Institutional	Not addressed	Regulations acting as barriers to innovation
Economic	Market dynamics Entry barriers Uncertainty and incomplete information about costs and benefits of innovation Price gap for environmental innovations at the beginning of the learning curve Network externalities causing a lock-out Public good nature of knowledge gives rise to problems of appropriating the benefits from innovation (e.g., risk of imitation)	Not enough risk capital and high capital costs
Technological	Not addressed	Inadequacies in the technology/ knowledge infrastructure Old and rigid technological capabilities within companies causing transition failures to new knowledge bases
Organisational	Not addressed	Insufficient entrepreneurship Actors not being able to coordinate joint actions
Behavioural	Not addressed	Unfamiliarity with and social

Source: Modified from Kemp (2011)

Five categories of barriers to eco-innovation can be identified in the literature (Montalvo 2008, Weber 1997). These categories are:

(1) Economic and financial (e.g. market demand, industrial standards, etc)
(2) Institutionnel (e.g. subsidies, incentives, etc.)
(3) Technological (e.g. absorptive capacity, limited R&D capacity, etc)
(4) Organizational (e.g. availability of management systems, collaboration and strategic alliances, etc)
(5) Behavioral, related to o habits, culture and idiosyncrasy (e.g. CEOs willingness to eco-innovate, consumption patterns, community pressures, etc.).

It is important to note that the perceived effect of particular drivers and barriers varies per industry, region and type of actor involved. They can be combined and can often have some degree of overlapping (Kemp et al., 2013).

A survey among European firms identified the most critical factors acting as barriers to eco-innovation[2]. Among the top five factors the respondents cited lack of internal funding, uncertain market demand, uncertain return of investment, lack of external funding and lack of access to public incentives and funds for eco-innovation.

The patterns highlighted in the survey have been explained by recent work from the OECD (2011; 2013), proposing that market mechanisms fail to deliver the optimal amount of eco-innovation at the appropriate time. In addition to negative *spillover* effects of innovation (e.g. due to high pace of imitation), the market may not adequately value the environmental benefit for the community. Hence, there are negative effects on investment.

Table 2 Main categories, definition and examples of barriers to eco-innovation and resource efficiency

Category	Market failure approach	System failure approach
Institutional	Not addressed	Regulations acting as barriers to innovation
Economic	Market dynamics Entry barriers Uncertainty and incomplete information about costs and benefits of innovation Price gap for environmental innovations at the beginning of the learning curve Network externalities causing a lock-out Public good nature of knowledge gives rise to problems of appropriating the benefits from innovation (e.g., risk of imitation)	Not enough risk capital and high capital costs
Technological	Not addressed	Inadequacies in the technology/ knowledge infrastructure Old and rigid technological

Source: Bastein et al (2014)

We consider that barriers are key to design of effective policy interventions, particularly in (eco)innovation policy design processes (Chaminade and Edquist, 2012; Heckert et al 2007). The latter can range from direct participation in the development and diffusion of innovation to indirect influence through setting the right framework conditions in the

[2] The Eurobarometer survey on 'attitudes of European entrepreneurs towards eco-innovation' included responses from 5,222 managers of SME's in 27 EU countries in the period January-February 2011. Economic sectors included (NACE rev 2.0): (A) agriculture, forestry and fishing; (C) manufacturing; (E) water supply, sewerage, waste management and remediation activities; (F) construction; and (I-56) food and beverage service activities.

innovation system (Del Rio, et al 2010). While the focus of this paper is on subsidies and grants to innovation, the following section introduces the broad range of policy support measures available for the promotion of eco-innovation.

2.2 Review of policy incentives for eco-innovation

At the political level concepts related to "eco-innovation", "green economy" and "transition to sustainability" have gained a strategic position into the global environmental policy agenda (OECD, 2011, UNEP, 2011). It is no surprise that eco-innovation is considered the engine of growth in green economy agendas in developed and also in some developing economies (Ekins & McDowall, 2014). This is because there are high expectations about their contribution to GDP and employment (EC, 2011)

Broadly speaking, eco-innovation is a field where the role of policy has been centered on the twofold objective of promoting environmental and economic change (Ekins, 2010; Kemp 2011). Therefore, eco-innovation can be seen as a policy objective on its own right (e.g. for the creation of new green ventures, clean-tech industry or eco-industry) or as a mechanism to achieve objectives of sustainable development (e.g. solution to an environmental problem such as soil degradation or sulfur emissions). Nonetheless, a great deal of attention have been traditionally paid to the public good of innovation *vs*. private costs to consumers, green taxation and environmental regulation (Kemp and Pontoglio, 2008).

Most OECD countries have developed supply side and demand side policies to support the process of eco-innovation, from invention to diffusion (OECD, 2008). Governments must consider how to support technology development (supply push)—for example, through R&D subsidies —and encourage demand through market creation (demand pull) for environmental technologies— for example, through public procurement (Del Rio et al 2012). Typical measures includes public investment in research, generic incentives to strengthen private investment in research and development, targeted measures to support specific goals or steer innovation towards given sectors, technologies or groups of firms, as well as measures to support commercialization and demand for green products and services (OECD, 2011). We briefly present in figure 2 an overview of the policy instruments for innovation, environmental care and their combination for eco-innovation, as well as the kind of instrument according to the supply or demand side.

Ekins (2010) observes that it is increasingly common to seek to deploy policy instruments in optimal policy 'mixes' or 'packages', in order to enhance their effectiveness across the pillars of sustainable development. Whilst the need for policy mixes is well-understood, the precise nature of them has to be determined on a case by case basis, raising difficult questions about the coordination and timing across the innovation cycle (Coenen and Díaz López 2010). According to Kemp (2011), eco-innovation policies should take into account the folowing aspects:

(1) policies have to be based on identified barriers (and failures),

(2) they have to prevent windfall profits,

(3) policies must consider and weight specific versus general support,

(4) they need to ensure adequate balance and timing of policy mixes and measures,

(5) they should provide targeted spending in areas where innovation is really needed,

(6) they have to promote missions for system innovation,

(7) in their conception and implementation, they should be supported by strategic intelligence,

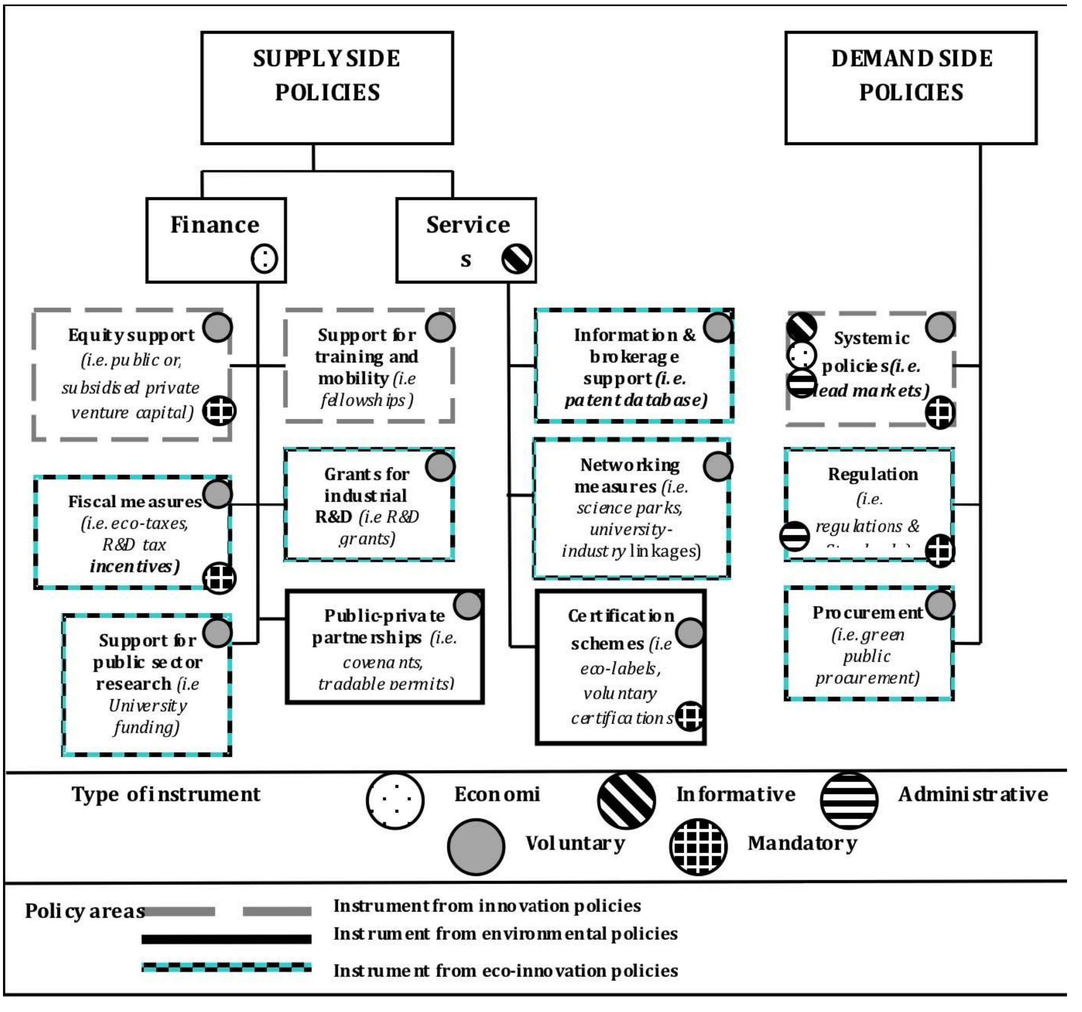
(8) they also have to ensure the availability and support of a wide innovation portfolio,

(9) They also have to enable policy learning and experimentation

(10) It is also important to ensure policy coordination and public-private interactions.

An example of policy integration is found in Europe, at the interphase between sustainable consumption and production and sustainable industrial policies. For over a decade now the European Union has promoted policy integration between the environmental and innovation policy domains (Rennings, et. al. 2001). While innovation policy has traditionally focused on growth and competitiveness, environmental policy deals with the challenges for environmental policy is to maximize the environmental benefits – to achieve an absolute decoupling as opposed to a relative decoupling. As noted by Kemp, et. al.(2013), environmental challenges are many and they compete with other challenges, such as gender equality, energy sufficiency, etc. Second, markets favor innovations requiring few changes in systems of provision and lifestyles of people. And third, information problems and problems of acceptance heavily constrain the set of possible government interventions.

Figure 2. Overview of policy instruments for eco-innovation



Source: Diaz Lopez et. al. (2008)

One of the pillars of the European eco-innovation agenda is the Eco-innovation Action Plan (EcoAP) (EC, 2011). This initiative aims at improving the market conditions for the uptake of eco-innovations. Seven actions are included in this plan: (1) environmental policy and regulation, (2) demonstration projects, (3) standards setting, (4) funding and support to small and medium companies, (5) international cooperation with emerging and developing economies, (6) new skills and knowledge for green jobs, and (7) innovation public-private partnerships. Of particular interest to the present study is the availability and effects of financial incentives for the development of eco-innovations.

3. Innovation policy in Mexico

Since de creation of the National Council for Science and Technology (CONACYT) in the mid-seventies, the Mexican government has focused on the implementation of different programs to enhance the national scientific and technological capacity. However, during more than two decades CONACYT's main strategies and programs focused on the creation of infrastructure for scientific research, the expansion of postgraduate programs for human resources formation, and the technological modernization of enterprises[3]

The different free trade agreements signed by Mexican government during the nineties with countries of North America, Latin America, the European Union and some other countries, allowed a greater presence of global corporations in the domestic market. This situation changed the landscape of competition since they had superior technological and innovation capabilities. In some sectors there were mergers and acquisitions of national companies by foreign competitors (chemical industry, for example). In others, processes of productive specialization were introduced and some companies became suppliers of parts and components for global chains of production, such as the automotive and electronics industries. In the commodity production sectors there was a high company mortality rate due to international competition with lower prices.

In 2000 some legal reforms in the domain of science and technology were promoted by the Mexican government, as well as the creation of the Special Program for Science and Technology (PECYT by its Spanish acronym). This program established the necessity of the growth of the country's scientific and technological capacity, the raise of competitiveness and enterprises' innovation capabilities. In contrast to previous programs of CONACYT, PECYT stressed the need to foster innovation and induce greater participation of the private sector in financing innovation activities, including SMEs. Consequently, we can say that innovation policy as such just began with the new millennium (Villavicencio 2009).

PECYT identified strategic areas of promotion from a sectorial perspective. These areas were related to aspects that concern national development such as: ICTs, biotechnology, communications, materials, construction, petrochemicals,

[3] See for instance contributions in Valenti (2008) and Villavicencio (2011)

manufacturing processes, natural resources, water problems, technology transfer and health. In order to tackle the exiting challenges on these areas, PECYT gave rise to a set of new programs that came to light as of 2001 with the participation of other government agencies. For example, we can mention the Institutional funds managed by CONACYT such as Avance (High Added Value in Business with Knowledge) and Fiscal Incentives; Sectorial Funds shared between CONACYT, State ministries and other government agencies; the Combined Funds for shared financing with each one of the 32 state governments of the country.

We should mention that in contrast to previous periods when many government agencies (energy, natural resources, health, etc.) established their own scientific and technological development programs in parallel with CONACYT, the PECYT funds represented an effort to establish policy coordination mechanisms in strategic sectors. Thus, in concert with other public agencies, CONACYT created 18 Sectorial funds to foster applied research and technological development. Some were created for the first time and others were improved versions of earlier programs. Each fund launches annual calls for the presentation of applied research projects according to areas of priority. Depending on the characteristics of the areas, some funds encourage collaborative projects, including, research networks and inter-institutional consortia.

From these sectorial programs, two are of interest to our research: the Semarnat Sectorial Fund shared by CONACYT and the Ministry of Environment and the Technological Innovation Fund (FIT). The first one supports applied research projects related to environmental problems carried out by research centers, universities and/or enterprises. The other supports R&D and industrial innovation projects carried out by enterprises. In 2003 the fund SEMARNAT-CONACYT supported only three projects (from around 120) explicitly addressing environmental innovation in companies (2 firms in total, one from the steel Industry and another from the mining Industry), the rest of the projects were individual researches from Universities without linkages to the industry (Diaz Lopez, 2004).

The Technological Innovation Fund (FIT). This program began operations in 2002 (with another name), with the main purpose of encouraging R&D and innovation projects in the productive sector. Large, medium and small Mexican enterprises as well as subsidiaries of transnational corporations that have gotten their registration on the catalogue of eligible enterprises can all compete in the calls, but they have to provide at least 50% of the project budget.

Since it was set up, the FIT has encouraged enterprises to create or improve their technological capabilities and provide the domestic market with new processes and products. In this regard, every year specific areas have been convoked, taking into account their economic and technological dynamism and, above all, the possible substitution of inputs, the generation of qualified jobs and the capacity to insert companies in chains of production with high value added. The main industrial areas where projects have been proposed and therefore supported are automotive and auto parts industry, electric and electronic, chemical and pharmaceutical products, machine tools, food and some other commodity industries like shoe and textiles.

After 2007 there were some changes in CONACYT strategies to foster innovation. The FIT modified its support modalities focusing mainly SMEs and prioritized technological areas instead of industrial sectors. Therefore nanotechnology, biotechnology, ICT and telecommunications, new materials, advanced manufacture, as well as alternative energy use/production were the principal areas of demand for calls.

By that time, a new program to encourage firms R&D and innovation activities was created. Called PEI (The Innovation Incentives Program), it replaced the previous Fiscal Incentives program which lasted from 2000 to 2006.This new PEI started financing projects from 2009 under three modalities of support: the first supports SME projects, the second one supports projects of large companies and the third supports projects of all size of enterprises in partnership with universities and research centers. Since its beginning the PEI has granted more than 2500 projects of enterprises belonging to several industrial sectors.

Now, with regards to the differences between PEI and FIT, we have three main aspects: one is related to the modality of support for linkages with universities and research centers that FIT does not prioritize; another is that PEI is managed exclusively by CONACYT. The third difference is that PEI's calls are now related to the states industrial challenges and priorities, and not necessarily related to high or emergent technological fields as FIT. This means that PEI could support SME's projects for incremental process and developments in traditional sectors as well as knowledge intensive sectors.

According to data we obtained from Conacyt up to 2015, PEI has founded more than 5000 technological and innovation projects for enterprises since 2007. This does not correspond to the same extent of enterprises for a simple reason. Projects and funds are approved for an annual cycle and one firm can in practice be granted for different projects in the same year, and for several years. Regarding FIT, the program has granted around 300 projects since 2007.

4. Survey of public funding for innovation in Mexico

Our research is aiming to analyze the existing empirical evidence coming from statistical data and CONCAYT'S reports of the granted projects. This analysis allows us to say that eco-innovation has not been part of the strategies for calls of proposals and priority areas of support, nor a generalized practice for enterprises.

Between 2002 and 2015, around 950 projects have been granted by FIT, mostly to improve or carry out new products and productive processes, albeit there have been also projects targeting the development of prototypes, the improvement of R&D infrastructure or the creation of R&D centers within companies. According to data more than 60% of the granted projects correspond to improved or new products and processes for the domestic market.

In terms of the number of existing industrial companies in Mexico, these data are not remarkable. However, if we consider that over the past 30 years new products and new technologies came mainly from abroad and that very few domestic companies performed R&D projects, we can consider that the Innovation Fund tends to modify the patterns of technological behavior in the country, not only because of the very nature of the projects it sponsors, but also since it fosters private investment in R&D and innovation activities. Despite the few projects supported, we can say that due to this program some enterprises are changing their behavior from what authors called passive or autarchic firms during the nineties (Arvanitis & Villavicencio 1998), into a more active ones performing technological learning processes and incremental innovation. Apparently by performing the projects, some enterprises attempt to substitute imported technology and supplies, by developing new technological capabilities to improve their production processes and products.

Regarding eco-innovation, from all supported projects by the FIT up to 2010, we only found a dozen dedicated to technologies, products and processes (new or improved) associated to eco-innovation.[4] These projects refer to different issues such as tire

[4] Public information regarding names or thematic issues on supported projects is not available. For these reason we could not have information up to 2015

recycling, cleaning soil processes, substitution of chemical inputs by biotech inputs for fertilization, as well as the use of inputs derived from agricultural biotechnology to replace plastics for packaging, disposable plates and cups; prototypes for the use of alternative energy sources (solar, bioethanol, biogas). We also find projects for new methods for treating and cleaning water pools using ozone, adaptation and improvement of bio-digesters to produce energy in tropical environments, the use of biotechnological inputs for cosmetics industry, soaps and detergents.

We can say that the enterprises running these projects, mainly SMEs, took advantage of the FIT as an incentive to develop technologies focused on environmental protection, but not because that has been a requirement of the program or criteria for funding. In interviews with the leaders of these projects, personal concern for seeking solutions to environmental degradation represented the reason for their accomplishment. In other words, although the FIT is an incentive for innovation, in terms of eco-innovation this program turns out to be an indirect incentive tapped by very few companies. Additionally, we made an exploration of 2500 sponsored projects by CONACYT from 2007 to 2012, in order to identify those related to eco-innovation. The data came from programs like PEI, FIT, and other programs that has disappeared around 2012. We found 161 projects, which represent 6% of the total. These projects can be classified as follow:

A) 69 projects on energy saving and/or new sources of energy (bioethanol, solar, wind, organic waste).
B) 31 projects for the design of machines, devices and/or processes to avoid environment pollution or to clean it (soil, water, air).
C) 30 projects on recycling of different materials (rubber, pet, plastic, paper, organic inputs, etc.).
D) 4 projects on plastic replacing by products derived from organic inputs (corn, sugarcane, agave, etc.) to manufacture different kinds of materials and biodegradable products (packaging materials, boxes, cups, napkins, etc.)
E) 27 projects to replace chemical and other toxic material by biomaterials, in order to manufacture cosmetics, hygiene & cleaning products, fertilizers, bioplastics,

Nevertheless, an analysis of PEI's granted projects for 2013-2015 showed new and interesting evidence. First, we found 90 projects related to energy (solar energy, thermic energy, energy efficiency, bioenergy, renewal energy, alternative energies and biomass). This can be explained by the recent changes in the regulatory frame in

Mexico regarding the production and distribution of energy, as well as the necessity to abandon petroleum as the main source of energy. We also found 37 granted projects related to issues like environmental engineering, soil treatment and recycling devices, techniques and materials. Finally, we found some other 36 projects related to new materials and biomaterials as inputs for diverse industries like the textile, chemistry, machine tools, automotive, plastics and resins, chemicals among others.

The sum of projects that we can relate to eco-innovation in this second group of projects granted by PEI, represents again like in the previous case around 6%. This is in our opinion a very small figure regarding the total projects granted, and even smaller if we consider the universe of industrial companies in the country.

Now, with respect to the classification of eco-innovations proposed in the first part of this article, the issues of the projects set out above denote elementary stages, both from the technological capabilities required, and from the nature of the results being obtained. They can be mostly related to the levels A (environmental technologies) and B (organization for innovation) of the classification shown. Even those projects pointing to energy issues can be positioned at the same levels. We can explain this situation considering that the existing policies in the country encourage innovation in general, but not eco-innovation specifically. The C and D levels imply a sort of collective and systemic actions, as well as a more interrelated policy instruments.

Furthermore, as some authors have pointed out, in countries like Mexico the general absence of technological capabilities in firms restricts the possible range of innovations only to improvements in products and processes, and to a lesser extent the development of new products to the national and / or global markets (Arvanitis & Villavicencio 1998; Contreras & Carrillo, 2011; Brown & Dominguez, 2013). Moreover, due to the industrial development pattern where commodities and low added value products have been representative on the domestic market, the technological path associated to that situation does not ensure robust technological and organizational learning capabilities.

In a certain way, the absence of a critical mass of companies with technological capabilities makes it difficult for policies to fulfill their objectives. Thus, instead of encouraging innovation, they help enterprises to improve their processes and to attain technological and organizational capabilities to efficiently perform production. Sometimes the funds help companies to improve their infrastructure for production and

R&D, sometimes they help them to substitute technical supplies by technological development efforts. However, eco-innovation does not come to appear the main strategy of companies when they submit projects to the CONACYT's programs.

There are other instruments to promote enterprises behavior in support of environmental protection in Mexico, such as tax reductions. Nonetheless, we have not been unable to obtain statistical information on the number of companies that have benefited from this type of instrument. What we can note is that these instruments are basically related to issues like energy savings, savings in water consumption and reduction of toxic waste, but they have no relation to eco-innovation as it has been defined in the first section of this paper. On the other hand, we have no way to know if the companies that have been benefiting from the FIT, PEI or other CONACYT's instruments were also benefited by tax discounts related to energy saving and reduction of toxic waste.

Some authors have emphasized the lack of coordination between the design and the implementation strategies of public policies in various matters (Casalet, 2005). Somehow, this is the case between the environmental protection policies and the innovation ones. The idea here is that when some market and institutional failures are not resolved by different policy mediations, the instruments designed to enhance innovation cannot be successful, and even worse, they can be contradictory between them, since they can play against other type of instruments. As far as we have analyzed policy instruments for innovation, by the kind of projects they support and by the rules and terms of references for grants, we able to point out a lack of concern of eco-innovation as policy strategy.

5. Final remarks

This paper offered a review of the innovation policies in Mexico trying to relate them as far as possible to what we defined as eco-innovation. In particular, we have analyzed financial incentives provided by the Mexican Council of Science of Technology for R&D and technology development. These incentives come from some programs fostering innovation capabilities in Mexican firms by means of subventions of at least half of the financial resources needed for the projects.

The incipient empirical results allowed us to show that eco-innovation today does not represent a strategy in the innovation policy programs, and it is not a target in most of the companies that carry out R&D activities in the framework of these programs. Unfortunately we were unable to access to broader statistical information about the behavior of firms in the protection of the environment, and consequently we cannot establish direct or indirect correlations between patterns of behavior of those firms performing incremental innovation and eco-innovation, with those using public policy incentives for reducing environmental degradation. For this reason, it is unclear to what extent the instruments of public policy that we have defined as incentives, converge to promote eco-innovation as goal.

For the enterprises, the eco-innovation does not seem to be a relevant matter related to their innovation practices, since very few enterprises that have taken advantage of CONACYT's financial grants for projects R&D and innovation are performing eco-innovation projects.

In terms of avenues for future research, it will be important to empirically validate the determinants and barriers to eco-innovation in Mexico. This could be done by analyzing qualitative data from in-depth interviews with key stakeholders and by performing case studies of companies with eco-innovation potential in specific sectors (e.g. recycling and waste). Here some questions can be raised. For instance, to what extent the regulatory frame does not compel to a more proactive eco-innovation behavior? Do eco-innovations entail new production costs given the industrial organization and the leading value chains (i.eg. suppliers, trade and imports)? In a more general perspective, to what extent costumer expectations and/or idiosyncrasy are not impelling producers to reduce waste and industrial pollution, and to manufacture more "green" goods for the national market?

For the time being, we have been able to identify several failures both at the market level (lack of demand) and the institutional setting (lack of coordination between echelons and instruments of policy) which acting simultaneously do not contribute to designate eco-innovation as an important area of development, to be included in criteria for funding within CONACYT innovation programs. In this sense, we can say that the existing barriers are hindering the gains of the few policy incentives we have found to promote eco-innovation in Mexico.

6. REFERENCES

ARVANITIS R. & D. VILLAVICENCIO, (1998), "Technological Learning and Innovation in the Mexican Chemical Industry: An Exercise in Taxonomy" in *Science Technology & Society*, New Delhi.-London, Vol. III(1), pp. 153-180

ACOST (1992). *Cleaner Technology*. London, HMSO. Advisory Council on Science and Technology.

BASTEIN, T., KOERS, W., DITTRICH, K., BECKER, J., & F.J. DIAZ LOPEZ (2014). Business barriers to the uptake of resource efficiency measures. Policy Options for a Resource-Efficient Economy, Deliverable D1.5. Delft, 88p.

BROWN F. & L. DOMINGUEZ (2013), "¿Tienen la industria aeronauttica mexicna las condiciones para integrarse a la cadena de valor internacional de alto valor agregado?" in Casalet M., (ed.), *La industria aeroespacial, complejidad productva e institucional*, FLACSO-CCS, México, pp. 135-162

CARRILLO G., R. CONSTANTINO & A. ROLDAN, (2010). "Incentivos de la política ambiental para ecología industrial en México". Paper presented at *SINNCO,* Guanajuato Mexico.

CASALET M., (2005) **"**New Institutional dynamics for the creation of a favorable environment for competitiveness: hope or reality?" in *Innovation: Management, Policy and Practice,* Sydney, pp. 321-335

COENEN, L. & DÍAZ LÓPEZ, F. J. (2010). Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. *Journal of Cleaner Production,* 18**,** 1149-1160.

CONTRERAS O. & J. CARRILLO (2011), "Las empresas multinacionales como vehículos para el aprendizaje y la innovación en empresas locales", in Bracamontes A..& O. Contreras, (eds), *Ciencia, Tecnología e Innovación para el desarrollo* económico, COLSON-COECYT, México, pp.325-356

DEL RIO, P., CARRILLO-HERMOSILLA, J., & T. KONNOLA (2010) Policy Strategies to Promote Eco-innovation. An integrated Framework. *Journal of Industrial Ecology*. Vol. 14, No. 4. p. 541-557

DIAZ LOPEZ, F.J. (2004). *Environment, Technical Change And Innovation. A Development Approach In The Latin American Chemical Industry: A Case Study In Mexico*", Oikos Phd Summer Academy 2004, 20 p

DIAZ LOPEZ, FJ (2009) Environment, technological change and Innovation. The case of the Mexican chemical industry. PhD Thesis. University of East Anglia, Norwich.

EC (2011) Communication from the Commission of the European Parliament. The Council, the European Economic and Social Committee and the Committee of the Regions. *Innovation for a sustainable Future - The Eco-innovation Action Plan (Eco-AP).* Brussels: Commission of the European Communitites

EKINS, P. (2010). Eco-innovation for environmental sustainability: concepts, progress and policies. *International Economics and Economic Policy,* 7**,** 267-290

HADJIMANOLIS A., (2003), "The Barriers Approacht to Innovation", en Shavinina L. (ed), *The International Handbook on Innovation*, Elsevier Science Ltd, pp, 559-573

HORBACH, J., RAMMER, C. & RENNINGS, K., (2012) Determinants of eco-innovations by type of environmental impact — The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, Volume 78, pp. 112-122.

KEMP, R. (2010) Eco-innovation: Definition, Measurement and Open Research Issues. *Economia Politica*, 397-420.

KEMP, R. (2011). "Ten themes for eco-innovation policies in Europe." S.A.P.I.E.N.S **4** (2): 1-19.

KEMP, R. & PEARSON, P. (2008) Final report MEI project about measuring eco-innovation. EU FP6 funded project 044513. Maastricht: UM-MERIT, ZEW, DTU, ICL, LEIA.

KEMP, R., F.J. DÍAZ LÓPEZ & R. BLEISCHWITZ (2013), Report on Green Growth and Eco-innovation. Report of the FP7 project EMInInn Macro-level Indicators to monitor the environmental impact of innovation, Delft and Maastricht, June, 80p.

LEFLAIVE, X. (2008). *Eco-Innovation Policies in Mexico*. OECD, Paris

MONTALVO, C. 2002. *Environmental Policy and Technological Innovation. Why Do Firms Adopt or Reject New Technologies?,* Cheltenham, Northampton, Edward Elgar.

MONTALVO, C., F. DIAZ LOPEZ, F., & BRANDES, F. (2011), Analysis of the Potential for Eco-innovation in Nine Sectors. Task 4 Horizontal Report 4. Delft: Europe Innova Sectoral Innovation Watch. Project on behalf of the European Commission, DG Enterprise and Industry.

OECD (1985) *Environmental Policy and Technological Change*, OECD, Paris

OECD (2008) *Eco-innovation Policies in Mexico*. OECD, Paris

OECD (2008). *National approaches for promoting eco-innovation: country profiles of eight non EU OECD countries*. OECD, Paris, 162p.

OECD (2009), *OECD Reviews of Innovation Policy: Mexico*, OECD Paris,

OECD (2010) *Eco-Innovation in Industry: Enabling Green Growth*. Parisganisation for Economic Cooperation and Development.

OECD (2011). Tools for Delivering Green Growth. OECD Paris.

RENNINGS, K. (2000). Redefining innovation -- eco-innovation research and the contribution from ecological economics. *Ecological Economics,* 32**,** 319-332.

RENNINGS, K., KEMP, R., BARTOLOMEO, M., HEMMELSKAMP, J. & HITCHENS, D. 2003. *Blueprints for an Integration of Science, Technology and Environmental Policy* (BLUEPRINT). Strata Project.

SKEA, J. 1995. Environmental technology. *In:* FOLMER, H. & GABEL, H. (eds.) *Principles of Environmental and Resource Economics. A Guide for Students and Decision-Makers Second Edition.* 2nd ed. Cheltenham, Northampton: Edward Elgar.

UNEP (2011). *Towards a Green Economy. Pathways to Sustainable Development and Poverty eradication*. Nairobi, United Nations Program for the Environment**:** 44.

VALENTI, G., (ed.), *Ciencia, Tecnología e innovación; Hacia una agenda de política pública*, FLACSO, México

VAN DEN BERGH, J. C. J. M., TRUFFER, B. & KALLIS, G. 2011. Environmental innovation and societal transitions: Introduction and overview. *Environmental Innovation and Societal Transitions,* 1**,** 1-23.

VILLAVICENCIO D., (2012), “Incentivos a la innovación en México: entre políticas y dinámicas sectoriales” en Carrillo, Hualde & Villavciencio., (Eds.), *Dilemas de la innovación en México*, COLEF-Red CCS, México, pp. 27-72

VILLAVICENCIO D., (2009), “Recent changes in science and technology policy in

Mexico: innovation incentives" en Martínez J.M. (Ed.) *Generation and Protection of Knowledge: intellectual property, innovation and economic development*, ECLAC, United, Nations, Santiago, pp. 263-290

VILLAVICENCIO D., (2011), "Retos para el diseño de políticas en México en EL marco de la innovación abierta" in Bracamontes A..& O. Contreras, (eds), *Ciencia, Tenología e Innovación para el desarrollo* económico, COLSON-COECYT, México, pp.73-102

WEBER, L., (1997) "Some reflections on barriers to the efficient use of energy". In *Energy Policy*, Vol. 25, pp. 833-835.