

# Technology-intensive firms in the transition to a new energy paradigm: Commercialization strategies, alliances and networks<sup>1</sup>

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Conference “The Governance of a Complex World”, Rotterdam, 24-26 October 2013

## Abstract

This paper focuses on the behaviour of new technology-intensive firms (NTIFs) in the process of developing research-based renewable energy technologies, and introducing them into the market.

Our main assumption is that the introduction of new energy technologies is closely connected with the creation of a variety of small technology-intensive firms that are the conveyors of these technologies and act as challengers to the statu quo.

We adopt a business model framework to study value creation and value capture by NTIFs, taking into account the context, where policy options, obstacles and opportunities impact the action and outcomes of the companies. The framework is applied to a group of 28 Portuguese NTIFs in several renewable energy areas.

*Key words: new technology-intensive firms; emerging renewable energy technologies; firms' alliances and networks; socio-technical transitions; technology commercialization.*

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<sup>1</sup> This paper draws on research carried out within the Project TESS - Transition to an environmentally sustainable energy system - The role of technology-intensive firms in the commercialization of emerging energy technologies, funded by FCT – Fundação para a Ciência e a Tecnologia (PTDC/CS-ECS/113568/2009), Portugal.

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## **1. Introduction**

This paper focuses on the behaviour of new technology-intensive firms (NTIFs) in the process of developing research-based renewable energy technologies, and introducing them into the market, thus contributing to the transition to a low carbon regime. It tries to identify the main business models adopted by these companies during that process.

Compared to previous major shifts, the current transition contains important specificities: the overwhelming inertia of the prevailing energy socio-technical system or techno- institutional complex (Geels, 2004; Unruh, 2000); the urgency to decrease carbon dependency, assumed by public powers and supported by organized social groups and a significant part of public opinion.

These two aspects have given rise to the setting of ambitious goals and the implementation of novel public policy devices at European and national levels. A European strategy for energy and sustainability was launched in 2007 aiming to stir technological innovation, the formation of new markets and the set-up of novel coordination schemes.

Our main assumption is that the introduction of new energy technologies is closely connected with the creation of a variety of small technology-intensive firms that are the conveyors of these technologies and act as challengers to the status quo (Bergek et al, 2008; Hekkert and Negro, 2009). This is because the exploitation of technologies that break-up with established technological regimes requires new knowledge and entails a high degree of uncertainty, thus creating opportunities for new entrants (Brown et al, 2007).

These new firms (and sectors) – which are often spin-offs from research organizations and large companies –, exploit advances in several scientific and technological domains and take advantage of the opportunities created by the new political and policy framework. Although facing huge obstacles, they have benefited from an array of incentives to renewables and from the creation and development of new markets (like those connected to biofuels, energy efficiency, buildings certification, and so on).

The transition literature is mostly focused on the macro level (regimes) (Markard et al, 2012, for a survey). It addresses small firms' strategies from the view point of regime shift. NTIFs either engage in alliances within the dominant regime (hybridisation); or develop radically new and divergent technologies (and products) in niches (niche accumulation) (Raven, 2007; Smith, 2007). These new energy technologies have reached different levels of maturity and market acceptance, implying different levels of opportunity for new firms (Hockerts and Wüstenhagen, 2010). Such sources of heterogeneity suggest that we will find distinct types of NTIFs.

We adopt a business model framework (Huijen and Verbong, 2013) to study value creation and value capture by NTIFs, taking into account the context, where policy options and a set of obstacles and opportunities impact the action and outcomes of the companies. The framework is applied to a group of 25 Portuguese NTIFs in several renewable energy areas. Data were collected through detailed interviews, based on a semi-structure questionnaire, with the founders or the CEOs, complemented with an extensive search for documentary information on the firms.

Based on the detailed information obtained, the analysis of the cases permits to identify: 1) the main opportunities and barriers that small companies have to face; 2) the existence of distinct behaviour forms according to several main analytical dimensions: business strategies; innovation strategies; access to external resources, through formal and informal relations; international relationships; 3) the impact of the recent turn in public policy, with the halting or decrease of most public incentives to renewables, on the NTIFs, in terms of their performance, strategies and expected development.

The results, which are analysed in light of the extant theoretical and empirical literature, may give insights into the role(s) played by NTIFs exploiting new energy technologies in the regime shift. They are also expected to contribute to further the knowledge about this emerging sector and to provide policy contributions.

## **2. Conceptual framework**

Small firms exploring and/or creating in a successful way entirely new technology have to deal with the problem of succeeding in the commercialization of their product or technology. Survival and development of those companies depend as much of their knowledge, creativity and productive abilities as of their capacity to design and implement adequate strategies to enter and sustain a position in the market.

This is even truer for firms in renewable energy areas that are, most of them during a period, working out of the dominant technological trajectories, that is, the dominant technological regime. In fact, they face the inertia and hardness of a strong installed socio-technical system, made of a complex of dominant technologies, powerful incumbent companies, large and dramatically costly infrastructures, vested interests' organisations, historically built consumer preferences, outdated policy options and installed routines (Unruh, 2000). In addition, the new technologies are usually cost ineffective at the start up and early stages, when it comes to compare their price performance to the one of the dominant technologies they wish to substitute. In a way, they are confronted with the (rival technologies) dilemma pointed out by David (David, 1985).

In order to survive and thrive in their innovation undertaking, the new technology intensive firms have to design and adopt an adequate business model, whose two main pillars are the most important challenges they face: value creation and value capture. The business model concept appeared in the 1970s but it was not until recently that it gained momentum. The spread of the use of Internet put at stake some industries, like music records and video sale and rental, not to mention film distribution and exhibition itself. On the other hand, it permitted the creation of new modes of business, like e-commerce. For both reasons, necessity and opportunity, the Internet stirred new forms of conceiving and carrying on business, that is, originated new business models, addressing the need to monetize Internet applications or to take advantage of new commercial opportunities. Examples of the former are e-Tunes and offerings that combine free access to basic products – software and others - and pricing for upgrades or adds-on. An example of the latter is E-bay, Amazon, e-travel

sites and many others. In such cases, innovation concerns the new business model itself.

This concept has been adopted by innovation studies, particularly when dealing with new complex technologies developed in parallel (or in niches, according to the transition literature), with the dominant regime. It means more than commercial and productive strategies together although it encompasses both.

Two recent comprehensive critical surveys (Zott et al, 2011; Klang et al, 2010) proceeded to a clarification of the domain, although recognizing that shortcomings and inconsistencies still subsist in the use of the concept.

The final definition proposed by Zott et al (2011:18-19) is the following: the business model is characterized as a new unit of analysis (closer to the firm or closer to the network); resorting to a holistic and systemic perspective; integrating activities (including boundary-spanning activities from the view point of the focal firm); and where the notion of value is central, both in regard to creation and capture. The main dimensions retained are then: value creation; value capture; organization of internal and bound-spanning activities of the firm; product market strategy; and obstacles and opportunities faced by the focal business.

This approach is much in line with Teece (2010), who writes that a business model describes the “design or architecture of the value creation, delivery and capture mechanisms employed” (Teece, 2010: 191). Some aspects of Teece’s elaboration are to be retained, both contextual (the customer power has increased, it is not just a question of the shifts in the customers habits and practices associated with the spread of the Internet; and intangible markets have grown) and internal (discovery, learning and adaptation are intrinsic to business models).

As to Klang et al (2010), they provide an approach to the business model concept that stands on three pillars: *classification; components and configuration*. Their approach draws on semiotics and chooses to study the syntactical dimension of the BM, defined as the relation of the BM with other same level theoretical categories (or signs), that is, concepts like strategy, value chain positioning, and so on.

Beginning with *classification*, and based on the reviewed literature, the authors draw a line between strategic management theories (mainly concerned with the understanding of value capture) and BMs, which are more focused on value creation (Klang et al, 2010:8). Another important significant difference is that strategy is more concerned with firm's "positioning vis-à-vis its competitors" (Klang et al, 2010:9), while BM puts an emphasis on "the patterns of its economic exchanges with external parties" (Klang et al, 2010:9). But in fact "despite these differences, the BM concept builds on ideas advocated by the main theoretical frameworks of business strategy, strategic management and entrepreneurship research" (Klang et al, 2010:9), aiming at becoming an integrative framework of a diversity of concepts and aspects (Klang et al, 2010:10), that includes also value chain analysis, the resource-based view of the firm, strategic network theory, transaction cost economics and aspects of Schumpeterian approach to innovation (Klang et al, 2010:10).

As to BM *components*, Klang et al define each of them as a "building block of the firm's core logic for creating and capturing value" (Klang et al, 2010:12). The list is very long, but a tripartite categorization should be retained: there are inside, interface and outside components of a BM (Klang et al, 2010:13). This is why strategic networks for value creation are a relevant part of the BM concept.

As to *configuration*, it deals with the relationships between the BM components. Klang et al (2010) address several views, sometimes rival sometimes potentially complementary: interrelatedness and interdependency; dynamic nature; coherence from the start versus interactive nature of the relationships; sequential nature of the configuration process; narrative approaches versus visual illustrations to explain causal mechanisms; functional perspectives based on the value chain (and not only); design scheme perspective, etc. (Klang et al, 2010:14-15).

Their criticism encompasses the way the three dimensions are addressed, and they identify three major gaps in the literature, which is faulty in regard to: 1) the relationships between BM and domains beyond strategic management and entrepreneurship; 2) the specific industry setting; 3) the fit and coherence of the configurations of the BM (Klang et al, 2010:15-16). In addition, they point out the

conceptual fragmentation and lack of theoretical (and empirical) grounding of the concept so far, which is also recognized by Teece (2010).

However, even if it still has a defective nature, the BM concept has become a strong heuristic device to study many new business phenomena like the one we are addressing in our paper. In fact: it provides an integrative framework of approaches and elements; it deals in an adequate way with the relationships between the (porous) current firm and its outside, via transactions, networks, outsourcings and under collaborative and competitive forms; it permits to understand the ways businesses had to adapt and transform to face recent and ongoing technological and societal major shifts (see Chesbrough, 2010).

### **3. Analytical framework**

We will draw on business models framework to address our research issue: to analyze the role played by young technology-intensive firms (NTIFs) in the transition to a new energy paradigm in Portugal and more specifically the options and actions they realize to enter in the market and sustain their positioning in there.

Here we explore the recognized main dimensions of the business model: the creation and capture of value. In this paper, we will present the empirical results relative to value creation, the remaining part being the subject of a further analysis.

A preliminary issue firms have to deal with is the definition of a value proposition, i.e., “the value created for users by an offering based on technology” (Chesbrough, 2010:355). That offering may assume several forms: a technology; a product; a service; a design; a technical solution; some form of technical assistance and maintenance. A second step consists of targeting a market segment and adopting a competitive approach regarding innovation, differentiation and pricing. Next, the firm has to decide either to produce in-house the whole product (or service) to be released or to resort to external agents, via collaborations, outsourcings, or to market transactions to obtain complementary parts, components and specialized services. In a certain way, this is often not a matter of choice but due to circumstance.

Particularly in the case of small innovative firms dealing with complex and novel technology, they have to specialize in specific segments of the production (or service) process or to remain upstream in the creation and development of technology (ies). In addition, these firms (and small firms in general) are constrained by holding a limited array of internal resources and skills, which propels them to realistically engage in formal and informal connections with selected partners to access the necessary resources. Before addressing the major issue of commercialization – Chesbrough (2010:354) wrote that “the economic value of a technology remains latent until it is commercialized in some way” – these companies have to find financial resources and to design an effective organizational device, where, of course, human resources and leadership are of utmost importance.

The transition to the downstream stage of commercialization consists of a survival test to the NTIFs. If they are not able to overcome this proof they will perish, no matter how good their technology is (see Chesbrough, 2010 on this matter). A recent paper addressed this issue in a comprehensive, systematic and thorough way (Conceição et al, 2012). In the paper it is argued that the commercialization strategies of spin-offs (confronted with the option of selling or licensing their technology in technology markets or engaging in the development of products or services based on that technology) requires investigating adequately two main topics: the protection of the new technology property rights; and the control of key complementary assets (Conceição et al, 2012). Analyzing a sample of 80 European spin-offs from six different countries and from several high-technology areas, and drawing on Teece (1986, 2006), and Gans and Stern (2003), among others, the authors find that complementary assets play a crucial role in the commercialization decisions (value capture) of the focal firms. In fact, they will not adopt a downstream strategy if they perceive these assets to be controlled by the incumbents or to be difficult to build or acquire (Conceição et al, 2012: 48). Appropriability (and the perception of it) appears also as a main dimension for decision formation, both regarding the efficacy of protection (and the perception of it) and the existence of own patents. But here many spin-offs can count on a kind of umbrella provided by their parent organizations, in case the patent has been filed by the latter.



Finally, the context has to be accounted for. It appears under three different forms: the obstacles and opportunities faced by the firms; the impact of policies; and the behavior of customers, whose role has been transformed as mentioned above.

Drawing on these contributions, we have built an analytical framework that is briefly presented in table 1. Here we articulate the two main theoretical dimensions of the business model – value creation and value capture – with the analytical dimensions associated with each, decomposed into categories. Finally, we show how we operationalised this framework with a set of built variables used in the questionnaire applied to the firms analyzed.

For operational purposes, we will define the business model through the combination of the two major attributes or analytical dimensions: offering definition and business strategy. Together they will define several types of BM, which we will then study empirically according to other relevant dimensions, like innovation strategy, networks built, and contextual dimensions such as obstacles and opportunities.

At a later stage we will proceed to the study, not only of value capture, but also of some other relevant analytical dimensions of value creation and context. This paper has for the time being an exploratory nature.

**Table 1 - Analytical framework of the Business Model**

Theoretical dimensions	Analytical dimensions	Categories
Value creation	Offering definition	Product, technology, services, design, solutions
	Business strategy	Innovation, differentiation, pricing
	Market segment targeted	Niche vs. broad market
	Innovation strategy	In-house Collaborative R&D Basic versus applied research versus experimental development
	Knowledge approach	Nature of knowledge Access vs. creation of knowledge
	Positioning in the value chain	Outsourcing vs. integration Specialization Vertical alliances
	Networks built	Importance of networks to the firms Nature of ties: informal or formal Resources accessed
	Resources and competences mobilized (includes funding)	Human resources Financial resources Equipment, facilities, infrastructure
	Organizational design	Forms
Value capture	Commercial strategy	Technology markets vs. downstream commercialization Pricing Marketing Legitimacy
	Property rights protection	Effectiveness of protection Forms of protection
	Complementary assets availability	Holding of key complementary assets Control of key CA Access through the market to key CA
	Alliances	Kinds of partner: incumbents, other NTIFs, etc.
	Outcome	Survival/growth Efficiency Profits
Context	Obstacles vs. opportunities	Types
	Policy measures	Impact Corporate political activity
	Customers behaviour	Preferences Habits Impact Interaction

## **4. Methodology**

### **Data collection**

Data were collected through detailed interviews with the companies' founders or CEOs. The interviews were conducted between May and September of 2013. They had an average length of 1.5 hours and were supported by a semi-structured questionnaire. The interviewees were asked to provide a brief history of the firm creation and then to give detailed information on the companies' activities and strategies, with emphasis in the processes of development and commercialization of technologies, products or services. Data collected through the interviews was complemented with an extensive search for documentary information on the firms.

### **Measures**

The firms were asked to specify their main current activity, selecting one of the following options: i) commercialize or licence technology, ii) develop and commercialize their own products, iii) integrate their own products with other products; iv) provision of services; commercialize third-party products/technologies. Based on this question two different categories were considered: one includes the development and commercialization of own products or technologies; the other includes the remaining activities.

The questionnaire also included a question for the company's business strategy. The respondents had to choose one of the following options: i) price-based competition; ii) quality/reliability-based competition; iii) technological innovation-based competition; and iv) design/project-based competition.

Regarding the company's innovation strategy, the questionnaire assessed the importance of several innovation practices, using a 7 point Likert-type scale varying from 1 = unimportant to 7 = very important. The innovation practices considered were: i) the introduction of products/services/technologies new to the market; ii) the introduction of products/services/technologies new to the firm; iii) improve significantly the existing products; iv) improve significantly the existing services; v) improve significantly the existing processes; vi) use new commercial forms; vii) develop

new or improved forms to organize or manage the energy production/distribution system.

Concerning the networks, the questionnaire included two questions to assess the importance of networks to access the resources needed for the companies' activities, also using a 7 point Likert-type scale varying from 1 = unimportant to 7 = very important. One question captures the importance of informal networks (informal contacts with individuals, such as acquaintances, professional contacts); the other captures the importance of formal networks (contractual relations with other organizations, including R&D projects, partnerships and joint-ventures). Seventeen different resources are considered.

Finally, the questionnaire addresses the obstacles and opportunities faced by the firms, using the same Likert scale. It includes one question to assess the importance of 12 obstacles and other to assess the importance of six opportunities.

## **5. Empirical setting**

### **Renewable energies in Portugal**

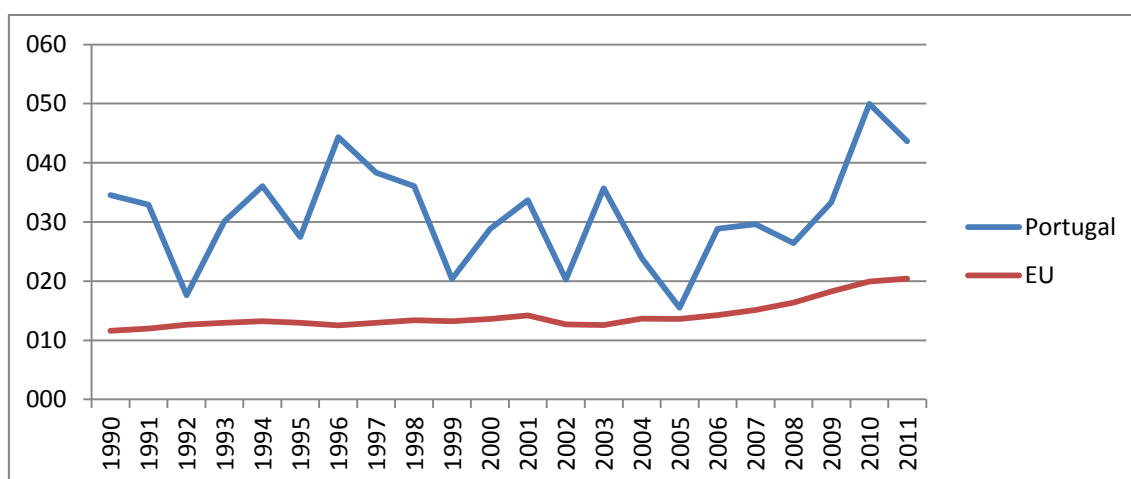
In the last 20 years, Portuguese energy policy has been shaped by the European perspective with the clear purpose of reducing the energy dependency and improving energy usage efficiency, whilst respecting environmental concerns and looking towards sustainable development. Since the mid-2000s, several demanding targets for the share of renewables in energy production and consumption were put forward for the EU countries, and the Portuguese government is targeting the ambitious value of 60% in the share of renewables in electricity production in 2020 (MEID, 2010).

Responding to those targets the Portuguese government made a strong investment in the production of electricity from renewable sources, using a varied set of policies and incentives: feed-in tariffs, priority access to electricity from renewable energy sources into the grid, fiscal incentives for adoption, public financing (through public investment or grants) and public competitive bidding (REN, 2011).

As a result of the current economic and financial crisis, the energy policy was revised. The government changed the support scheme for renewable energy, with an adjustment of tariffs and the reduction or even elimination of fiscal incentives and public financing. These changes may slow down the development and implementation of renewables, as illustrated by the experience of other countries (Negro and Hekkert, 2010).

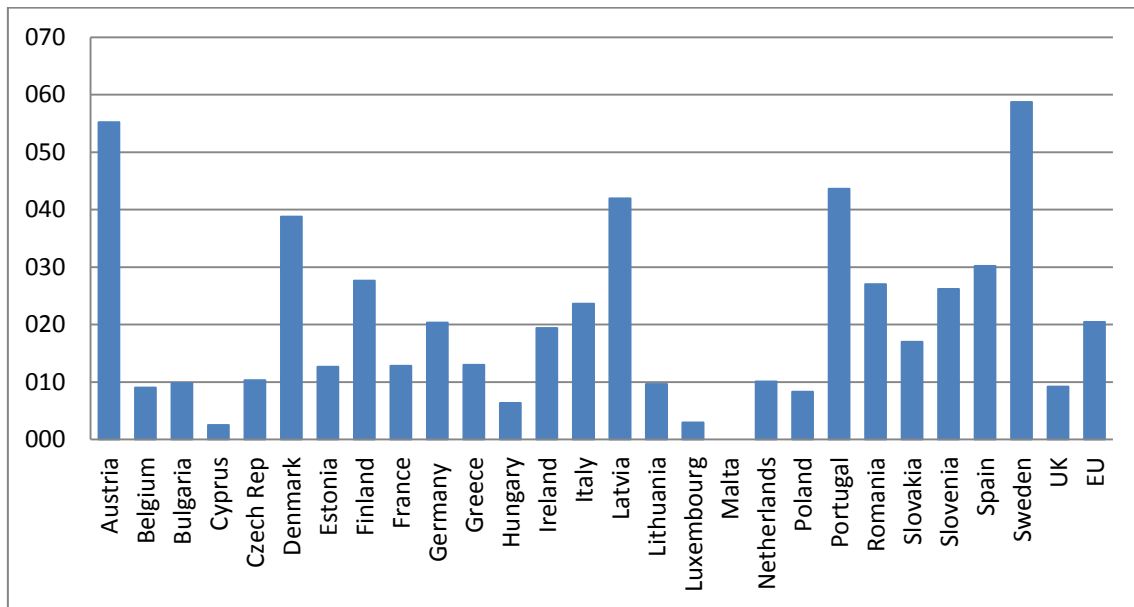
Since the mid-2000s it is possible to observe a steady growth of the penetration of renewable energies in the country's electricity production (Figure 1), which in 2011 reached more than 40% corresponding to the third largest value in the EU (Figure XXX).

**Figure 1 – Electricity generated from renewable sources in Portugal and EU, 1990-2011**



Source: Eurostat

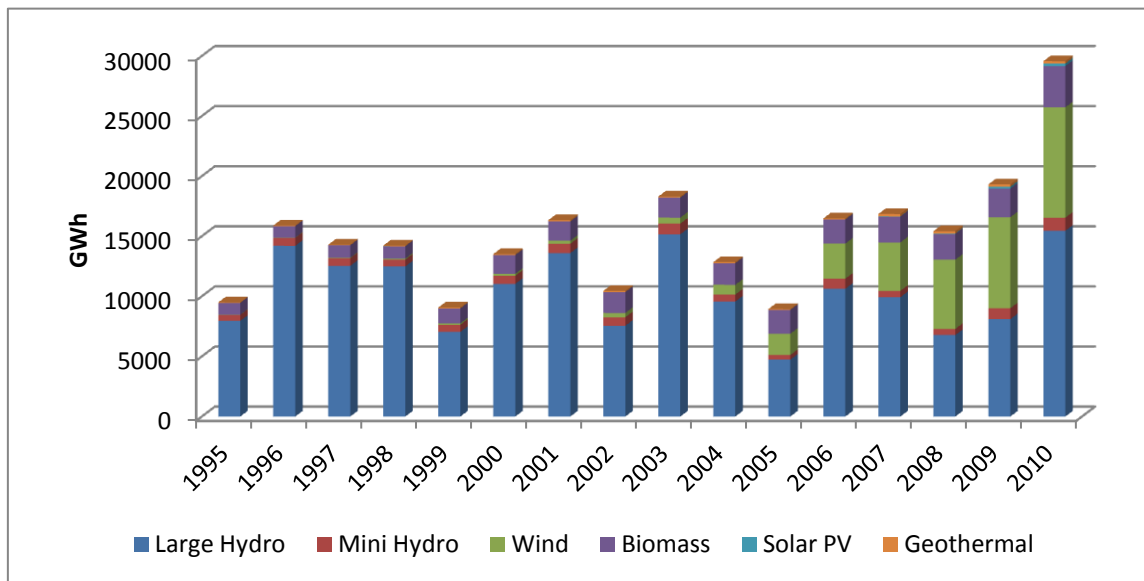
**Figure 2 – Electricity generated from renewable sources in EU countries, 2011**



Source: Eurostat

Figure 2 shows the evolution of the electricity generated from renewable by source, since 1995. It displays the Portuguese longstanding tradition in conventional hydropower (> 10MW). This source is characterized by a high volatility, since it is heavily dependent on variations in rainfall and precipitation. That volatility is visible in the Figure that also reveals the contribution to a higher penetration of renewable energy sources is mainly based on wind (with an annual growth rate of 53% between 1995 and 2010). Other renewable sources have had a smaller contribution, despite some of them recorded high growth rates. In fact, solar PV registered a high annual growth rate in the period under analysis (48%), (mainly due to the installation of two large power plants completed in 2007 and 2008), but its contribution remains small (less than 1% of renewables).

**Figure 3 - Electricity generated from renewables, by source type**

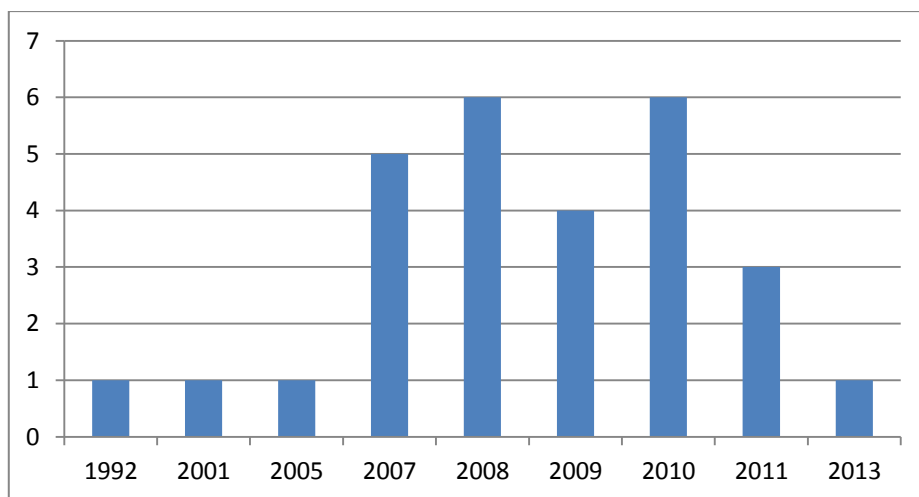


Source: Portuguese National Directorate for Energy (DGEG)

### Sample

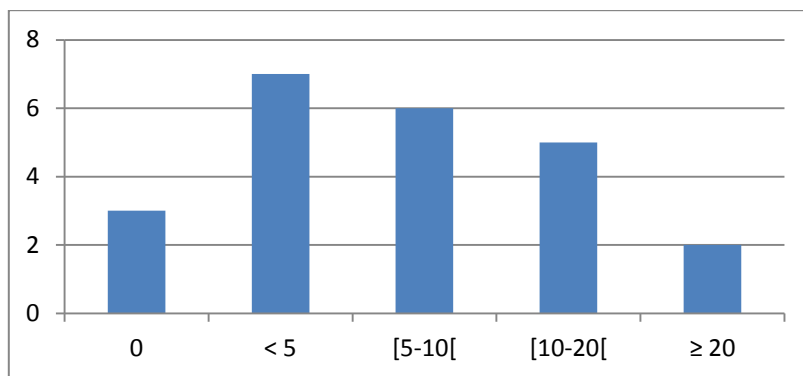
The empirical analysis of this paper draws on a sample of 28 Portuguese companies: These companies are developing and commercializing renewable energy technologies or products. They are relatively young (75% were created between 2007 and 2010, Figure 4) and are located in three main regions - the Great Lisbon area (42%), Centro and Norte (21% each). The remaining is dispersed across the rest of the country.

**Figure 4 – Year of firm creation**

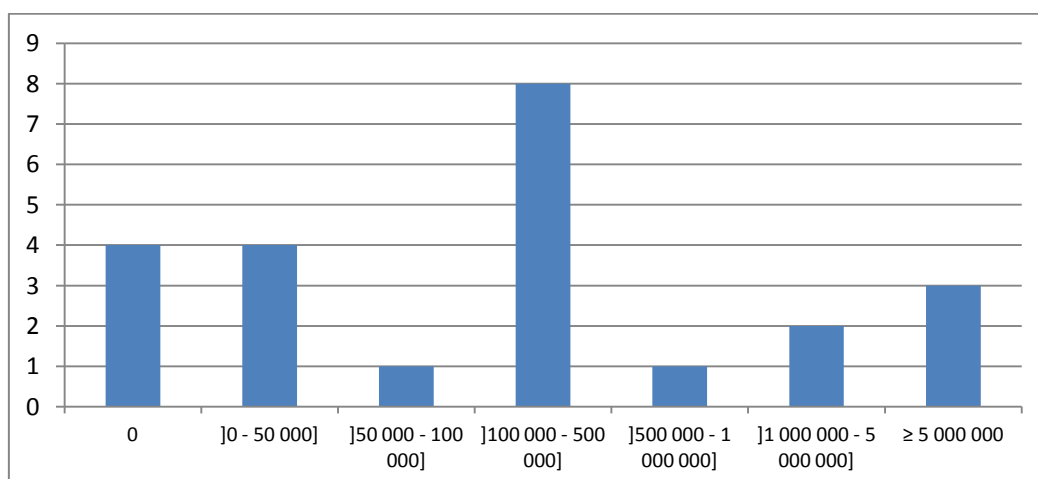


Most of the companies are very small. In terms of employment (Figure 5), the majority has 10 employees or less, the average number being 8. More than 10% do not have yet any full-time worker. In terms of turnover (Figure 6), the average of the sample is 1.2 million Euros but most of the firms (78%) had a turnover under 1 million Euros (78%). Four companies are not yet in the market, focusing their activity on the development and test of technology.

**Figure 5 – Number of workers, in 2012**



**Figure 6 – Turnover, in 2012**





More than half of the companies export. The main markets are EU and Portuguese speaking (CPLC) countries. On average, the weight of exports on turnover is 22.5% but for 18% of the companies exports represent 90% or more of revenues.

In terms of origin of the company, 68% are spin-offs, either academic (43%) or corporate (25%). The development of the initial RES technology was mainly made in collaboration with other organization (32%), in-house (29%) or was originally developed in the parent organization and then transferred to the company (29%, with 18% transferred formally and 11% informally). Only 11% of the companies referred that the initial RES technology was developed by a third-party organization.

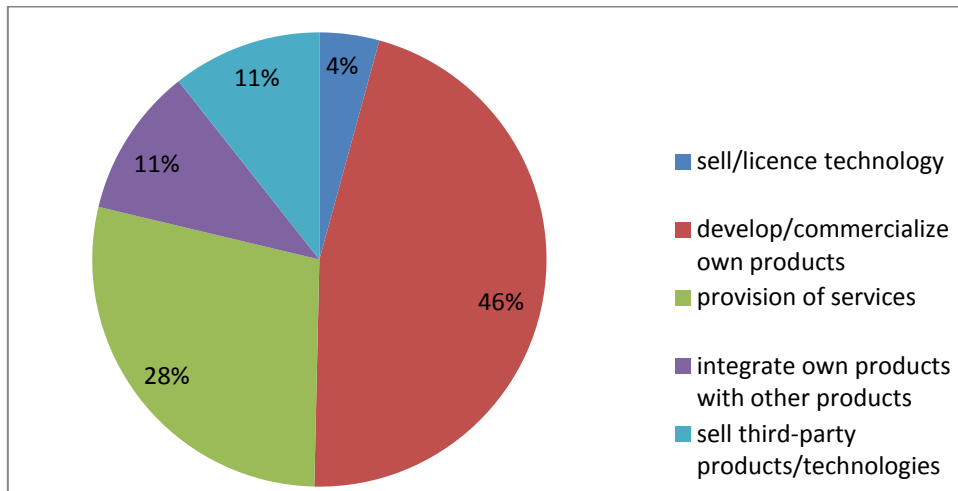
89% of the companies perform R&D activities, usually combining research (basic or applied) with development (including project or product feasibility or product performance evaluation). However, 18% only perform research activities. In terms of investment, the average percentage in R&D in the 2012 turnover was 43%. When asked if the technology used was applied for patent registration, 57% answered “no”, 29% have one patent application and 14% have two patent applications either pending or registered.

## **6. Results**

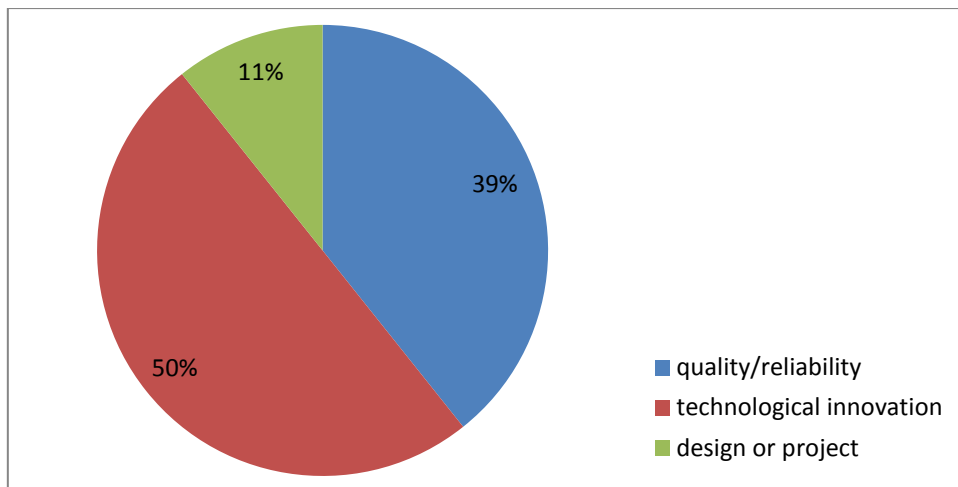
### **Business models**

As mentioned above, in this paper we consider that BM can be operationalized combining two dimensions related with value creation: the offering definition and the business strategy. Figures 7 and 8 depict the options made by the companies regarding these two dimensions. A large share of these companies considers the development and commercialization of own products as their main activity (Figure 7). Half of the companies' main activity is developing/selling own products or technologies, while the other half provide services, integrate their own products with third-party products or commercialize third-party products. Regarding the business strategy, the choice of differentiation by innovation is the most frequent situation (Figure 8). None of the companies adopts a strategy based on price competition.

**Figure 7 – Offering definition**



**Figure 8 – Business strategies**



If we consider both dimensions simultaneously, we have six different possibilities, as shown in table xx. Since only three companies are following a business strategy based on design/project differentiation and thus the number of cases falling in cells (3) and (6) are very low, we will exclude them in the remaining empirical analysis.

**Table 2 – Business models**

	technological innovation	quality/reliability	design/project
development and commercialization of own products or technologies	(1) 10 companies	(2) 3 companies	(3) 1 company
provision of services, integration of own products, commercialization of third-party products	(4) 4 companies	(5) 8 companies	(6) 2 companies

Summing up, four different business models emerge in these companies:

- Develop own products or technologies based on the differentiation by technological innovation – BM1
- Develop own products or technologies based on the differentiation by quality/reliability – BM2
- Provide services, integrate or commercialize third-party products based on the differentiation by technological innovation – BM3
- Provide services, integrate or commercialize third-party products based on the differentiation by quality/reliability – BM4

In the remaining of this section we will analyse the differences and similarities across the four business models, considering three dimensions mentioned in the literature and highlighted in our analytical framework: the innovation strategy, the use of networks to access resources and the perception of the context (obstacles and opportunities).

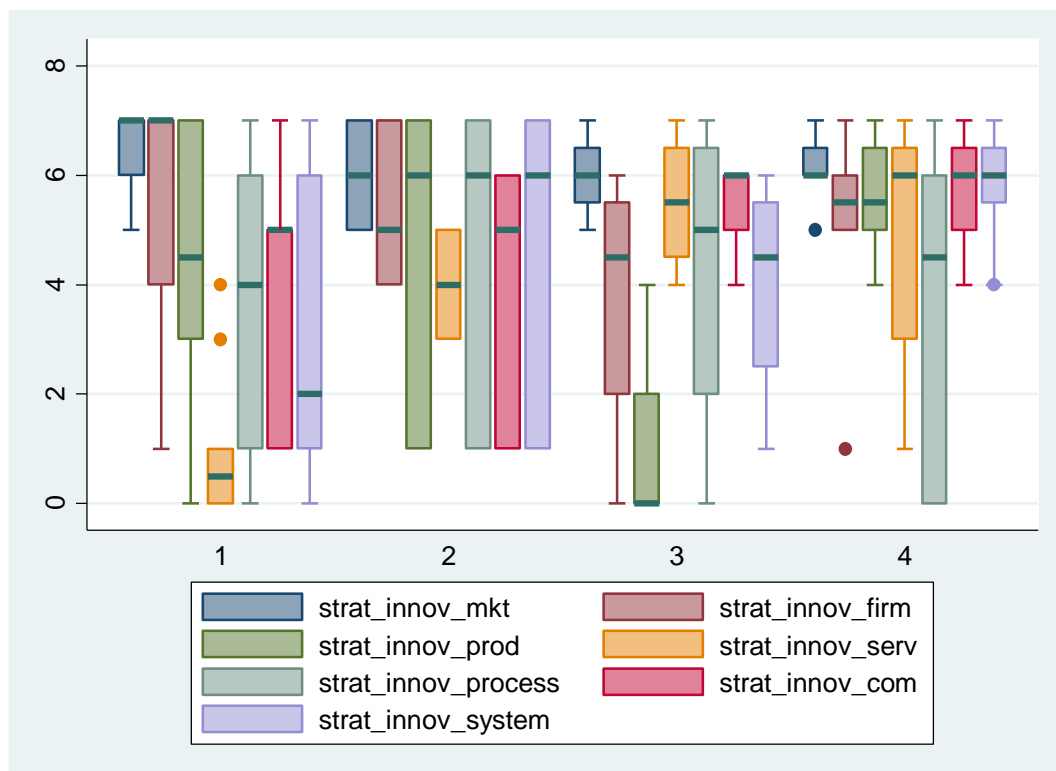
### **Business models and innovation strategy**

According to the literature, the innovation strategy is a relevant aspect of value creation. Thus, we expect that BMs differ in terms of the mix of innovation activities performed by the companies. To capture those differences we have used box plot graphics, since they enable to compare distributions between several groups – in this case BM – using quartiles. The box plot graphic exhibits values for maximum, minimum and median values. It also indicates the degree of dispersion and skewness in the data,

and identifies outliers (represented by dots in the graph). Figure 9 shows the box plot for innovation strategy.

It is possible to observe some regularity across the four groups: in all BMs, companies attribute a high importance to the development of products, services or technologies that are new to the market (stat\_innov\_mkt), since the median is always greater than 5, in a 1-7 scale. The use of new commercial forms (stat\_innov\_com) is also valued by companies in all BMs (the median is always greater than or equal to 5).

**Figure 9 – Innovation strategy**



However, we can observe clear-cut differences between the BMs regarding the importance attributed to the several innovation activities:

- Companies adopting the BM1 give more relevance (relatively to other groups) to the introduction of new products, services or technologies new to the market (stat\_innov\_mkt) or new to the company (stat\_innov\_firm). At the same time, they attribute low importance to the improvement of existing

services (stat\_innov\_services) and to the development of new or improved forms to organize or manage the energy production/distribution system (stat\_innov\_system).

- Companies adopting the BM2 are those that value more the activities related with the improvement of existing products (stat\_innov\_prod) or processes (stat\_innov\_process).
- Companies adopting BM3 attribute very low importance to activities related with the improvement of existing products (stat\_innov\_prod).
- Companies adopting the BM4 are those that value more the activities related with the improvement of existing services (stat\_innov\_serv).

### **Business models and networking**

Networks and their role in access to resources and competencies are also acknowledged, in the literature, as a relevant dimension to value creation. In this research, respondents were asked to rate the importance of informal and formal networks to access a set of 17 resources and competences. Globally, these companies recognize the relevance of networks for this purpose, especially in the case of informal relations.

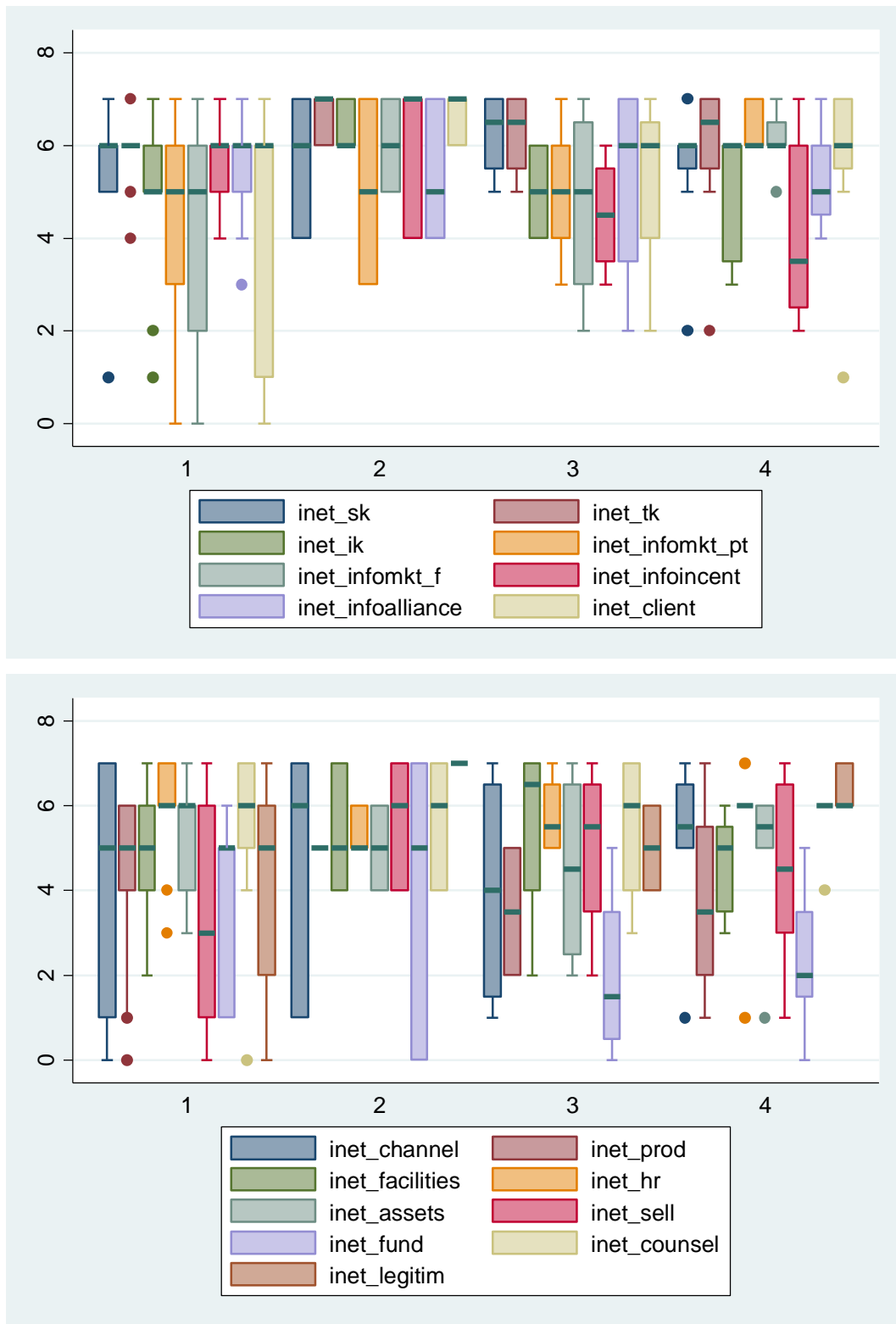
It is possible to observe some differences across the BMs in the importance attributed to networks, both in case of informal and formal relations. Beginning with informal networks (Figure 10), it is possible to observe that:

- Companies adopting BM1 typically value informal networks to access resources and competences (the median is greater than or equal to 5, with the exception of contacts to sell the product/service/technology – inet\_sell – that assume the lowest value of all groups). The companies in this group value more than the ones in other BMs the role of informal networks to access human resources (inet\_hr) and other complementary assets (inet\_assets).
- Companies adopting BM2 also attribute high importance to informal networks (the median is always greater than or equal to 5). They value relatively more the role of informal networks to access technological knowledge (inet\_tk), information about incentives (inet\_infoincent), clients (inet\_client), distribution

channels (inet\_channel) and legitimacy (inet\_legitim). Conversely, they value relatively less the role of networks to access human resources.

- Companies adopting BM3 give more relevance (relatively to other groups) to the role of informal networks to access scientific knowledge (inet\_sk) and facilities and technical resources (inet\_facilities). For them, networks are relatively less important to access distribution channels, other complementary assets and external funding (inet\_fund).
- Companies adopting BM4 attribute relatively more importance to the access to information about Portuguese clients (inet\_infomkt\_pt) and relatively less importance to the access to information about incentives (inet\_infoincent).

**Figure 10 – Informal networks**

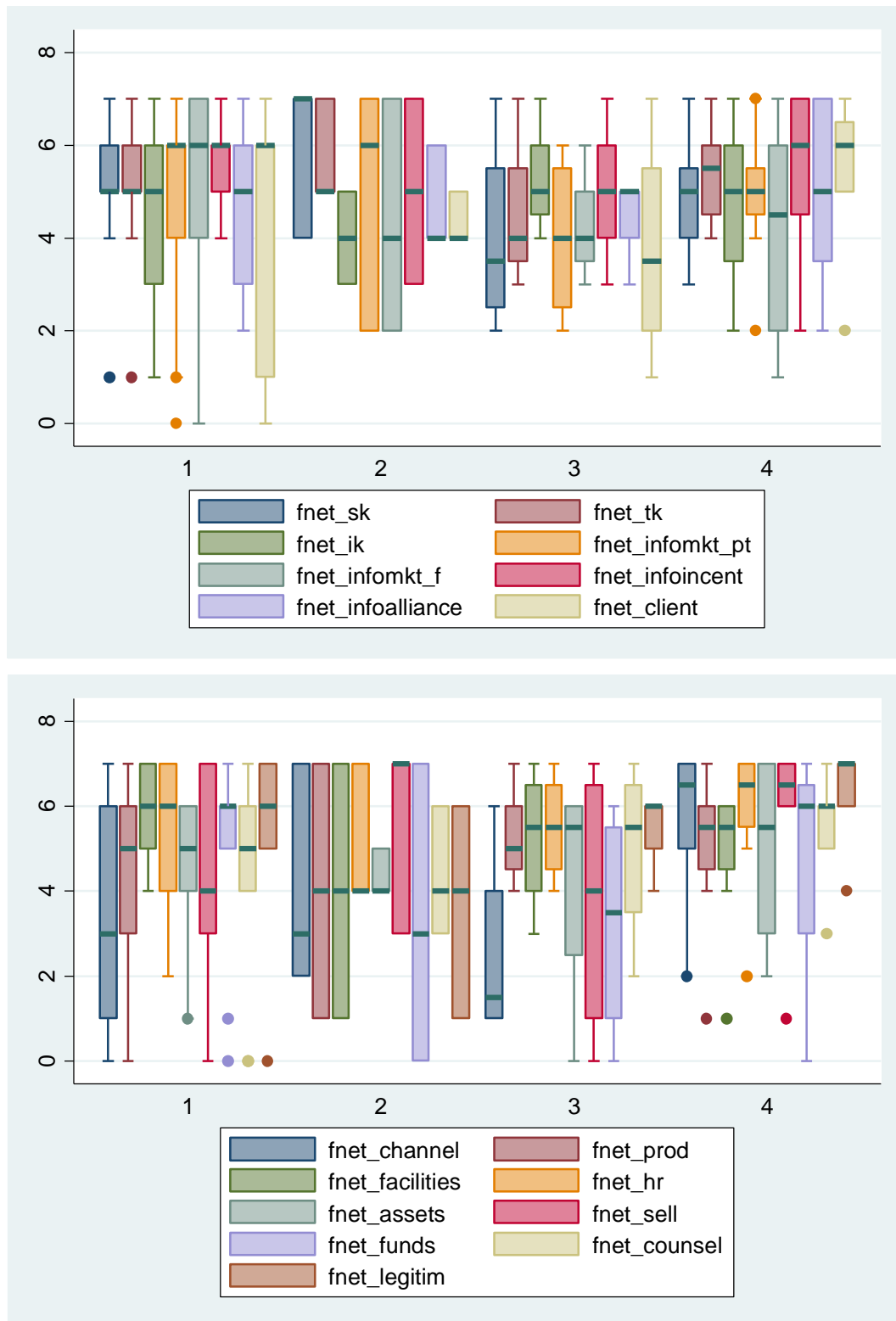


Regarding formal networks (Figure 11) our results show that:

- Companies adopting BM1 give more relevance (relatively to other groups) to the role of formal networks to access information about foreign clients (fnet\_infomkt\_f) and to facilities and technical assets (fnet\_facilities)
- Companies adopting BM2 consider, relatively to the other groups, that formal networks are more relevant to access scientific knowledge (fnet\_sk) and clients (fnet\_client). Conversely, they consider networks less relevant to access a large number of resources and competences, namely, international knowledge networks (fnet\_ik), information about alliances (fnet\_infoalliance), production capacity (fnet\_prod), facilities and technical assets, human resources (fnet\_hr), other complementary assets (fnet\_assets), external funds (fnet\_fund), counselling (f\_netcounsel) and legitimacy (fnet\_legitim).
- Companies adopting BM3 give less relevance (relatively to other groups) to the role of formal networks to access several resources: scientific and technological knowledge, international knowledge networks, information about foreign clients, clients and distribution channels.
- Companies adopting BM4 give more relevance (relatively to other groups) to the role of formal networks to access several resources: technological knowledge, distribution channels, production capacity, human resources, counselling and legitimacy.



Figure 11 – Formal networks



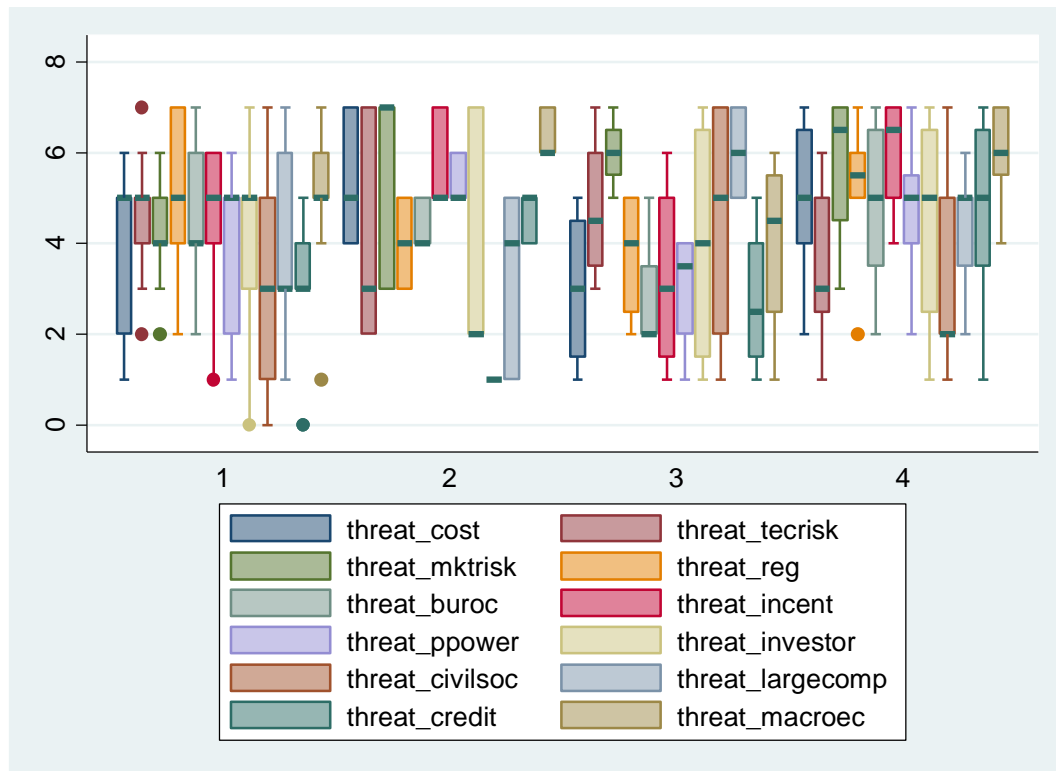
## **Business models and context perception**

In terms of context, we consider both the obstacles and opportunities faced by the companies.

Regarding obstacles (Figure 12), the results show some differences between the four groups of companies:

- For companies in BM1, relatively to other groups, technical risk (threat\_tecrisk) is a more relevant obstacle, while market risk (threat\_mktrisk) and the actuation of large energy companies (threat\_largecomp) are seen as less important.
- For companies in BM2, relatively to other groups, market risk (threat\_mktrisk) is a more relevant obstacle, while the non-acceptance of the company's technology by investors (threat\_investor) and by the civil society (threat\_civilsoc) are seen as less important.
- For companies in BM3, relatively to other groups, the non-acceptance of the company's technology by the civil society and the actuation of large energy companies are the more relevant obstacles, while the relative cost of the company's technology (threat\_cost), the bureaucracy (threat\_buroc), the reduction of incentives to the adoption of renewables (threat\_incent), the access to credit (threat\_credit) and the macroeconomic conditions (threat\_macroec) are seen as less important.
- Companies in BM4 give more importance (relatively to other groups) to the following obstacles: regulation, fiscal and legal factors (threat\_reg), bureaucracy, reduction of incentives to the adoption of renewables and macroeconomic conditions. Conversely, they give less importance to the technical risk obstacle.

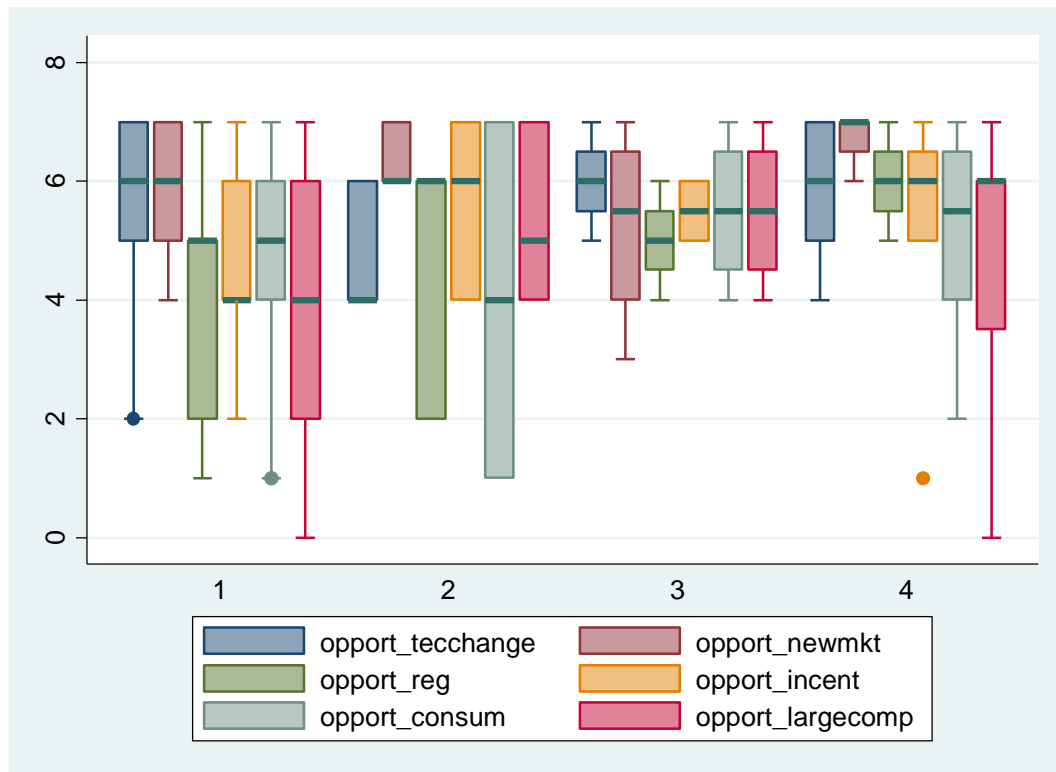
**Figure 12 - Obstacles**



Finally, the analysis of Figure 13, also reveals difference across BM in terms of the perception of opportunities:

- For companies in BM1, relatively to other groups, public incentives (opport\_incent) and the conduct of large energy companies (opport\_largecomp) are less relevant opportunities.
- For companies in BM2, relatively to other groups, technological change (opport\_tecchange) and the change in the consumer behaviour (opport\_consum) are less relevant opportunities.
- For companies in BM3, relatively to other groups, the emergence of new markets (opport\_newmkt) is a less relevant opportunity.
- For companies in BM4, relatively to other groups, the emergence of new markets and the conduct of large energy companies are more relevant opportunities.

**Figure 13 - Opportunities**



## 7. Discussion and conclusion

This exploratory study based on a sample of 28 new technologies intensive firms operating in new energy technologies is still at a preliminary stage. However, some conclusions and insights for future research may be drawn.

First, we have suggested an approach to the firms' behaviour based on the business model concept. This framework permits to integrate a diversity of analytical dimensions that contribute to the understanding of value creation and value capture by the firms, embedded in a context moulded by policy and involving obstacles and opportunities. This framework appears as a fruitful heuristic device, although it is generally recognized in the literature that it is still to be extended and improved, through both theoretical and empirical work.

Using this framework, we were able to find the existence of four different business models in the group of firms. These business models were built according to two major dimensions, the main activity of the company (i.e. the definition of its main offering, technology, product or service) and the business strategy (innovation oriented or quality oriented). With this typology we studied how firms conduct their innovation strategy, use their informal and formal networks to access resources and perceive the obstacles and opportunities put to them. We found quite contrasted patterns across the four business models, which seems to indicate that this kind of demarche is useful to understand how NTIFs act in the respective markets.

Further research will integrate other dimensions regarding value creation and will address value capture, not considered empirically in this paper. In addition, we will extend the sample and will explore more thoroughly the patterns observed, resorting to more sophisticated techniques.

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