Dominant business models of young firms in the renewable energy sector

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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, thus contributing to the transition to a low carbon regime.
We adopt a business model framework to study value creation by NTIFs, taking into account the context, where 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, trying to identify the main business models adopted by them.
Results reveal the existence of different business models in the exploitation of renewable energy technologies by these firms. They also reveal that companies adopting different business models perceive differently the context where they operate, namely in terms of obstacles and opportunities assessment.
These results are expected to contribute to further knowledge about the business models, which are emerging in this highly innovative new sector, giving insights into the strategies deployed by NTIFs exploiting the new energy technologies associated with the regime shift, and thus contributing to strategy and policy formulation aiming at developing the renewable energy sector.

Keywords: new technology-intensive firms; business models; obstacles and barriers to innovation; renewable energy technologies.

1 Introduction

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 these 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, historically built consumer preferences, out-dated 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).
We consider 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 (Bergek et al, 2008; Hekkert and Negro, 2009). These new firms – which are often spin-offs -, exploit advances in several scientific and technological domains and take advantage of the opportunities created by the new policy framework. Although facing obstacles, they have benefited from an array of incentives to renewables and from the development of new markets (biofuels, energy efficiency, buildings certification, and so on).
In order to survive and thrive in their innovation undertaking, the new technology-intensive firms have to design and adopt an adequate business model (BM), whose pillars are the most important challenges they face: value creation and value capture. This paper adopts the BM framework (Zott et al, 2011; Klang et al, 2010, Teece, 2010, Chesbrough, 2010; Huijen and Verbong, 2013) to study value creation by NTIFs. In addition, it addresses how the companies perceive obstacles and opportunities and how this perception differs across firms adopting different BMs.

2 Business model: the concept and its operationalization

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 permitted the creation of new modes of business, like e-commerce and stirred new forms of conceiving and carrying on business, that is, originated new business models.

More recently, the BM concept has been adopted by innovation studies, particularly when dealing with new complex technologies developed in parallel (or in niches), with the dominant regime. This means far more than putting together commercial and productive strategies, although the concept comprises 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 el 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 boundary-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).

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 on-going technological and societal major shifts (see Chesbrough, 2010).

In this paper we explore only the main dimensions of the business model: the creation of value, the remaining aspects being the subject of further analyses. Regarding value creation, 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, firms have 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 engage realistically in formal and informal connections with selected partners to access the necessary resources. Before addressing the major issue of commercialization – since, as Chesbrough (2010:354) wrote, "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 (Chesbrough, 2010). A recent paper addressed this issue in a comprehensive, systematic and thorough way (Conceição et al, 2012). 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 behaviour 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 value creation with the analytical dimensions associated with it, decomposed into categories. Finally, we show how we operationalized this framework with a set of built variables used in the questionnaire applied to the firms analysed.

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 contextual dimensions such as obstacles and opportunities.

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	New to the market /or new to the firm/or significant improvement Product /service /process /commercial /organizational innovation
	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
Context	Obstacles vs. opportunities	Types
	Policy measures	Impact Corporate political activity
	Customers behaviour	Preferences Habits Impact Interaction

3 Method

3.1 Empirical setting and sample

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

In order to promote the diffusion of renewable technologies, the Portuguese government has used 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 it is possible to observe a steady growth of the penetration of renewables in the country's electricity production, which in 2012 reached 48% corresponding to the fourth higher position in the EU.

The above mentioned policy efforts towards the development and dissemination of renewables and the expansion of the renewable electricity production sector created a highly favourable environment for the creation of new firms exploiting advanced energy or energy-related technologies.

The empirical analysis of this paper draws on a sample of 28 Portuguese companies that are developing and commercializing renewable energy technologies or products. They are relatively young (75% were created between 2007 and 2010) and small: in terms of employment, the majority has 9 employees or less; in terms of turnover, 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.

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

In terms of origin of the company, 68% are spin-offs, either academic (43%) or corporate (25%). The development of the initial renewable energy technology was mainly made in collaboration with other

organizations (32%), in-house (29%) or was originally developed in the parent organization and then transferred to the company. Only 11% of the companies referred that the initial technology was developed by a third-party organization.
A large share of the companies (89%) performs R&D activities, usually combining research (basic or applied) with development (including project or product feasibility or product performance evaluation). In terms of investment, the average percentage in R&D in the 2012 turnover was 43%. In terms of IPR, 43% of the companies have at least one patent application either pending or registered.

3.2 Data collection
Data were collected through detailed interviews with the companies' founders or CEOs. The interviews were conducted between May and September 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 and then 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.

3.3 Measures and techniques
The empirical analysis draws on a set of measures that capture three dimensions of the analytical framework (Table 2): offering definition, business strategy and obstacles vs. opportunities.
Regarding the dimension "offering definition", 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 third-party products; iv) provision of services; v) commercialize third-party products/technologies. Based on this question, two different categories were considered: one includes the development and commercialization of own technologies or products; the other includes the remaining activities.
Concerning 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.
The questionnaire addresses the obstacles and opportunities faced by the firms, using a seven point Likert scale. It includes one question to assess the importance of twelve obstacles and other to assess the importance of six opportunities.

Table 2 – Description of the variables

Dimension	Variable	Description	Values
Offering definition	Commercialize or license of technology	The main current activity is to commercialize or to licence technology	Binary 1=yes; 0=no
	Develop and commercialize own products	The main current activity is to develop and commercialize their own products	Binary 1=yes; 0=no
	Integrate own products with those of third-parties	The main current activity is to integrate their own products with other products	Binary 1=yes; 0=no
	Provision of services	The main current activity of the company is to provide services	Binary 1=yes; 0=no
	Commercialize third-party products/technologies	The main current activity is to commercialize third-party products/technologies	Binary 1=yes; 0=no
Business strategy	Price-based competition	The business strategy is based on price competition	Binary 1=yes; 0=no
	Quality/reliability-based competition	The business strategy is based on the quality or reliability of products/services/technologies	Binary 1=yes; 0=no
	Technological innovation-based competition	The business strategy is based on technological innovation	Binary 1=yes; 0=no
	Design/project-based competition	The business strategy is based on the characteristics of the design/project	Binary 1=yes; 0=no

Obstacles	Cost	Importance attached to the relative cost of the company's technology as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Technical risk	Importance attached to the technical risk as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Market risk	Importance attached to the market risk as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Regulation, fiscal and legal factors	Importance attached to regulation, fiscal and legal factors as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Bureaucracy	Importance attached to bureaucracy as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Reduction of incentives to the adoption of renewables	Importance attached to the reduction of incentives to the adoption of renewables as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Non-acceptance of technology by public authorities	Importance attached to the non-acceptance of technology by public authorities as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Non-acceptance of technology by investors	Importance attached to the non-acceptance of technology by investors as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Non-acceptance of technology by the civil society	Importance attached to the non-acceptance of technology by the civil society as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Conduct of large energy companies	Importance attached to the conduct of large energy companies as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Access to credit	Importance attached to access to credit as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Macroeconomic conditions	Importance attached to macroeconomic conditions as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
Opportunities	Technological change	Importance attached to technological change as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all
	New markets or segments	Importance attached to the emergence of new markets or segments as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all
	Regulation	Importance attached to regulation as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all
	Public incentives to renewables	Importance attached to public incentives to renewables as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all
	Favourable conduct of large energy companies	Importance attached to the conduct of large energy companies as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all

We expect that companies adopting different BMs will perceive differently the context, in terms of obstacles and opportunities. To capture those differences we have used box plot graphics, since they enable to compare distributions between groups – in this case the four BMs – 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).

4 Results

4.1 Business models

As mentioned above, we consider that BMs can be operationalized combining two dimensions related with value creation: the offering definition and the business strategy. A large share of the companies considers the development and commercialization of own technologies or products as their main activity (Figure 1). Regarding the business strategy, the choice of differentiation through innovation is the most frequent situation (Figure 2). None of the companies adopts a strategy based on price competition.

Figure 1 – Offering definition

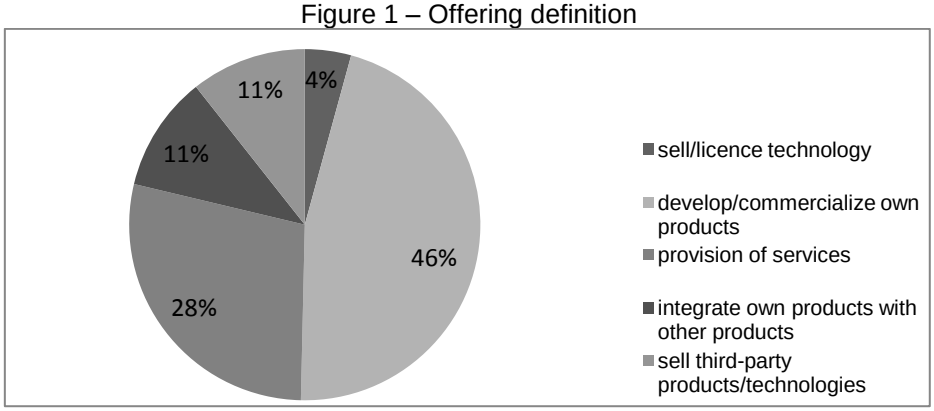
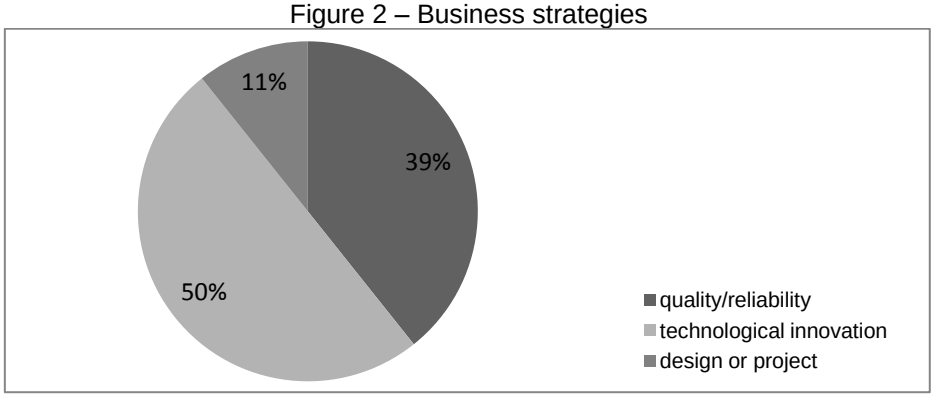


Figure 2 – Business strategies



If we consider both dimensions simultaneously, we have six different possibilities (Table 3). 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) is very low, we will exclude them in the remaining empirical analysis.

Table 3 – Business models

Business strategy / Offering definition	Technological innovation	Quality/ reliability	Design/ project
Development and commercialization of own technologies or products	BM1 10 companies	BM2 3 companies	1 company
Provision of services; integration of own products with third-party ones; commercialization of third-party products	BM3 4 companies	BM4 8 companies	2 companies

Therefore, four different business models emerge in these companies:

- Developing own technologies or products based on technological innovation – BM1
- Developing own technologies or products based on differentiation by quality/reliability – BM2
- Providing services, integrating or commercializing third-party products based on technological innovation – BM3

- Providing services, integrating or commercializing third-party products based on differentiation by quality/reliability – BM4

Table 4 shows the main characteristics of the firms in each BM. Firms adopting BM1 are young and small and often academic spin-offs. Most of them do not export, and in average exports account for 12% of their turnover. All companies perform R&D activities and this group exhibits the higher R&D intensity. Furthermore, companies tend to patent their technologies.

Companies adopting BM2 show different characteristics. They are very often corporate spin-offs and are older and larger than those adopting BM1. In fact, BM2 integrates the largest companies in the sample. All companies in BM2 export and exports account for nearly all their sales. Additionally, although all companies carry out R&D activities, its intensity is quite weak. Also the number of companies that patent their technologies is lower, compared to the previous group, although representing two thirds of total firms.

All companies adopting the BM3 are academic spin-offs. This group of companies exhibits the highest average age, but sales are still low. Half of the companies export although with a very modest expression. In fact, sales are oriented to the domestic market. The importance of innovation is reflected on the existence of R&D activities in all companies, with a strong intensity in terms of turnover, and on the hiring of PHDs.

Table 4 – Firms' characteristics by business model

Characteristics	BM1	BM2	BM3	BM4
Academic spin-offs (%)	40	33	100	25
Corporate spin-offs (%)	10	67	0	38
Age (average; years)	3.4	6	8.5	4.8
Employees in 2012 (average)	2.1	37.5	8.8	8.6
Turnover in 2012 (average; 10^3€)	62	6800	510	1599
Exporting companies (%)	40	100	50	50
Exports in turnover in 2012 (average; %)	12	96	8	13
Companies with R&D (%)	100	100	100	75
R&D expenses in turnover in 2012 (average; %)	86	3	48	15
Companies with patents (%)	80	67	0	38
Companies with PHDs (%)	0	0	50	13

BM4 group shows the lowest number of academic spin-offs. Companies are relatively young, but reveal the second largest average turnover. As in the previous group, half of the companies export, but the foreign market has a small expression. This is the only group in which not all companies conduct R&D activities. However, some patent their technologies and/or hire PHDs.

4.2 Business models and context perception

As expected, the results show that NTIFs adopting different business models perceive differently the context where they operate. Beginning with the perception of obstacles (Figure 3), the results clearly show the following differences between the four groups of companies:

- For companies in BM1, the comparative costs of their technologies, technical risk, regulatory, fiscal and legal fiscal factors, reduction of incentives, non acceptance of their technology by both public authorities and investors, and macroeconomic conditions are seen as the major obstacles. Relatively to other groups, technical risk is a more relevant obstacle, while market risk and the conduct of large energy companies are seen as less important.
- For companies in BM2, market risk is by far the most important obstacle, followed by macroeconomic conditions and, at a distance, by comparative costs, reduction of incentives, non acceptance of their technology by public authorities and access to credit. Relatively to other groups, market risk is a more relevant obstacle, while the non-acceptance of the company's technology by investors or by the civil society is seen as less important.
- For companies in BM3, market risk, the conduct of large energy companies, non acceptance of their technology by the civil society, technical risk and macroeconomic conditions are perceived as the more important obstacles. Relatively to other groups, the non-acceptance of the company's technology by the civil society and the conduct of large energy companies are considered as more relevant obstacles, while the relative cost of the company's technology, the bureaucracy, the reduction of incentives to the adoption of renewables, the access to credit and the macroeconomic conditions are seen as less important.

- Companies in BM4 value more obstacles such as market risk, reduction of incentives, macroeconomic conditions, and regulation, fiscal and legal factors, while they attribute a low importance to the non acceptance by the civil society and technical risk. In comparative terms, they give more importance (relatively to other groups) to the following obstacles: regulation, fiscal and legal factors, bureaucracy, reduction of incentives to the adoption of renewables and macroeconomic conditions. Together with companies in BM2, they give much less importance to technical risk.

Results also reveal differences across BMs in terms of the perception of opportunities (Figure 4):

- For companies in BM1, the most important opportunities are technological change and the emergence of new markets, while public incentives and the conduct of large energy companies are perceived as neutral.
- For companies in BM2, the most relevant opportunities are seen as the emergence of new markets and public incentives, while technological change and changes in the consumer behaviour are faced as neutral.
- For companies in BM3, technological change is perceived as the most relevant opportunity, while regulatory aspects are attributed the least importance in creating opportunities. In relative terms, this group faces the emergence of new markets as a less relevant opportunity than the other groups.
- For companies in BM4, the emergence of new markets is the most relevant opportunity. In relative terms, this is the group which attributes more importance to the conduct of large energy companies in creating opportunities.

Figure 3 - Obstacles

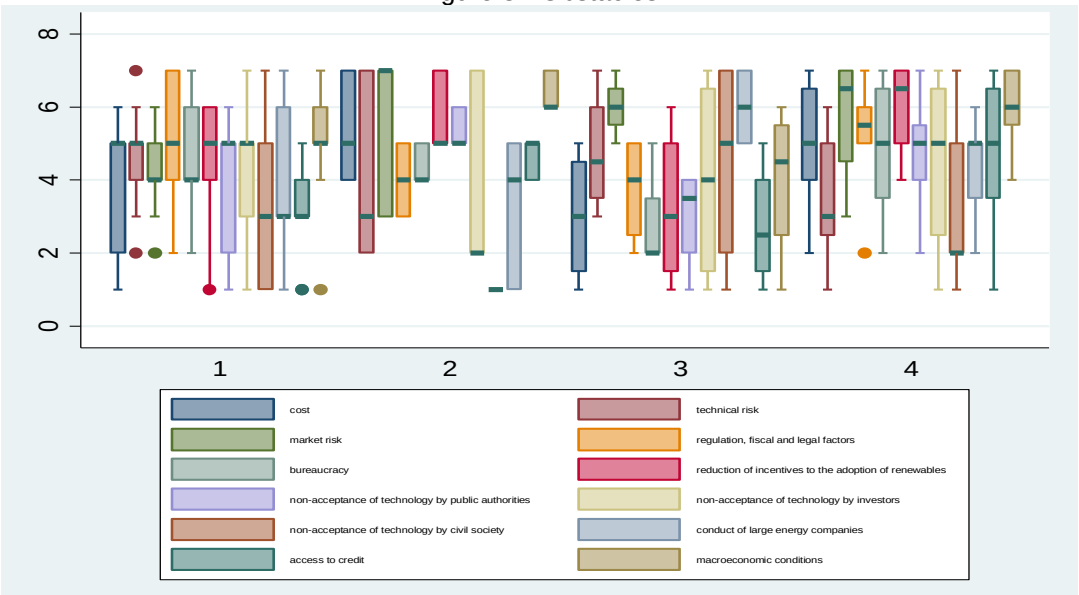
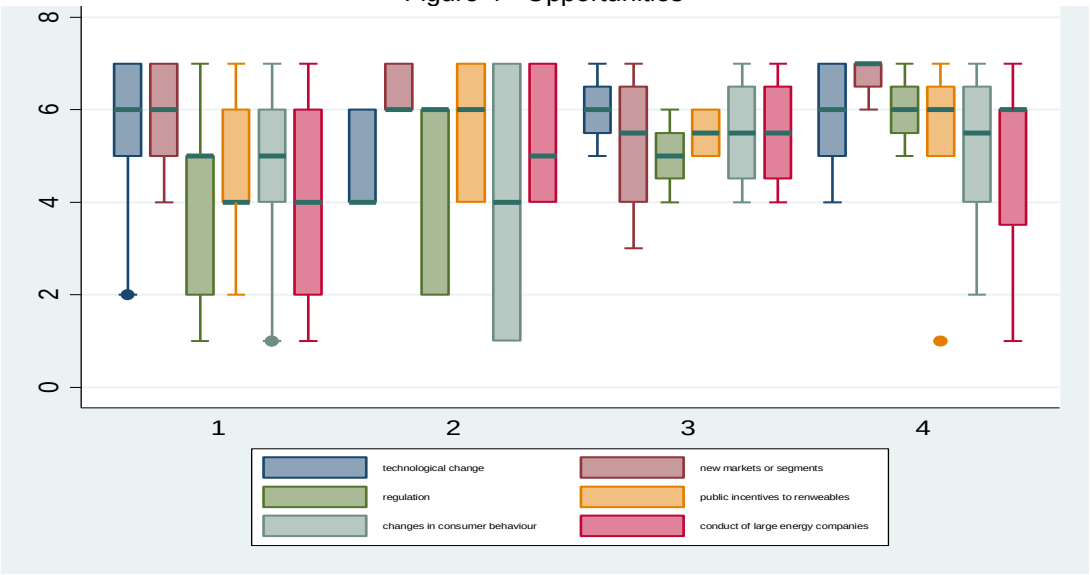


Figure 4 - Opportunities



5 Conclusion

This exploratory study based on a sample of 28 new technology-intensive firms (NTIFs) 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. Therefore, it appears as a fruitful heuristic device, although it is generally recognized in the literature that it has 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 a group of firms in the Portuguese renewable energy technologies sector. 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 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 and therefore contribute to sustainable transitions.

Further research will integrate other dimensions regarding value creation and will address value capture, not considered 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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