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CORDINATORE Prof. Piergiuseppe Morone

The transition towards a sustainable economy. Assessing the role of regulation and social networks

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Dottorando
Dott. Pasquale Marcello Falcone

Tutor Scientifico
Prof. Piergiuseppe Morone

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1. Introduction

"Are we on a sustainable energy path? Not unless we make considerable changes."

OECD (2001)

1.1 Context and research aim

Developed countries are currently operating in an unsustainable manner (OECD, 2001). Governments and communities are becoming increasingly concerned about issues like climate change and access to water, and they recognise that vital technological systems such as electricity, transport, and water supply need to change.

However, this presents a formidable challenge. Incumbent technologies are embedded in a network of socio-technical elements that, oftentimes, supports the incumbents and discourages alternatives. We cannot simply replace "old" technologies with more "sustainable" versions because new technologies need to be compatible with existing infrastructure, enabling technologies and cultural practices.

Researchers have named this condition "lock-in" and regard it as a problem because it makes it difficult for society to respond to issues like climate change and to move in a more sustainable direction (Rip and Kemp, 1998, Unruh, 2002). In this context, sustainability could be understood as creating a policy process that avoids "lock in" and can lead to a win-win situation, in which social welfare as well as the private net benefits of firm adhering to such regulation can be increased (Porter Hypothesis). However, while the relevance and the impact of environmental regulations in producing environmental benefits is widely known, it may, indeed, induce several discussions that rely on the relationship between such environmental regulations and competitiveness. More specifically, as stressed by neoclassical economics, environmental regulations, in achieving the socially optimal environmental protection, may reduce economic agents' profitability and competitiveness, due to the higher expenses and constraints on industry behaviour being not a solution but rather a further cause of "lock-in". In fact, the effects of environmental policies on the development and spread of new technologies may, in

the long-run, be among the most important determinants of success or failure of environmental protection efforts (Kneese and Schultze, 1975). Therefore, technological change may become a fundamental source of long-term competitive advantage and successful international competitiveness for the economic agents that innovate, stimulated by the need of complying with a new stringent environmental regulation.

Moreover, recently, researchers have tried to develop others methods for overcoming lock-in. In particular, the issue of how to promote and govern a transition toward sustainability, i.e., a fundamental transformation towards more sustainable modes of production and consumption, have received increasing attention over the past 10-15 years. A promising body of theory and practice is the Strategic Niche Management (SNM). SNM provides actors' with a conceptual framework for socio-technical change and suggestions for action. In proverbial terms, SNM is a way of understanding *why a square peg won't fit into a round hole* and suggests how actors can influence the direction of change to achieve a mutual fit (Hoogma et al., 2002). Transitions scholars state that for several new technologies, mainly with sustainability aims, market niches and consumer demand are not immediately available since the innovations are not always trivial changes from the prevailing set of technologies, but differ deeply from them. SNM was therefore designed to entail the management of particular type of innovations: (1) socially desirable innovations serving long-term goals such as sustainability, (2) radical novelties that face a divergence with regard to existing infrastructure, user practices, regulations, etc. It is indeed for this reason that SNM scholars see real-world experimental projects, in which various stakeholders collaborate and exchange information, knowledge and experience, as important devices that precede market niche development (Schot and Geels, 2010).

The research has focused mainly on the analysis of particular forms of sustainable transitions, identifying and highlighting possible environmental strategies and public policies to encourage environmental innovations that enable transitions of socio-technical systems towards more environmentally friendly using existing literature, a game theoretical model and a case study of Italian bio-plastic in order to better understand the basic dynamics of a transition process.

The remainder of this chapter presents the research design (including research questions and thesis aims) and explains how the thesis will meets its aims.

1.2 Research design

Four questions guided the research that is presented in this thesis. They were:

Q.1 *What insights are available from existing literature that can provide responses on the debate of the effects of environmental regulation on industries' competitiveness in sustainable transition processes?*

This question is addressed in Chapter 2 where I review relevant literature and propose initial responses to the identified relation.

Q.2 *How theoretical applicable are these responses to the introduction of an environmental standard? Does the case offer additional insights that allow a win-win situation to arise?*

These two questions are addressed in the theoretical Chapter 3 and resumed in the concluding chapter (6).

Q.3 *What insights are available from existing literature on how to promote and govern a transition toward sustainability?*

This question is addressed in Chapter 4 where the approaches to study transitions are reviewed.

Q.4 *How applicable is the SNM approach to the case of the Italian bio-plastics sector? Which is the potential development of the bio-waste technological niche and which are the factors that may hinder the full development of such technological niche?*

These two questions are addressed in the empirical Chapter 5 and resumed in the concluding chapter (6).

The aim of this thesis is to answer these questions by showing that:

- The existing literature offers a range of insights of the various ways of qualifying and measuring the effects of environmental regulation on market forces in the

transition process towards sustainability. Specifically, Neoclassical, Porterian and Managerial (RBV). The empirical evidence does not reveal that any strand of research has strongly succeeded over the others, even though, since the early nineties, the Neoclassical Approach, and the vision that it has traditionally supplied the negative effects of the application of environmental policies on the competitive dynamics, have been put seriously in question by scholars and research groups who opposed empirical evidence in contrast to the aforementioned neoclassical assumptions. However, the relationship might vary depending on the source of the regulation, its form and the environmental assets it is seeking to protect and, also depending on the characteristics of the businesses and sectors concerned.

- Even in a neoclassical framework (i.e. in a framework of vertically differentiated duopoly under complete information and competition *à la* Bertrand), it is possible to find environmental policies that may simultaneously improve environmental quality and increase the profit of firms given the presence of green consumers that patronise the good they choose to buy, i.e., they specifically care about the environmental impact of the good they buy. In order to obtain our results we concentrated on a particular environmental policy instrument: an environmental standard that forces firms to produce the high quality variant of the product. This instrument is able to determine a shifting toward a new profit-enhancing configuration by solving a coordination failure.
- The "sustainability transition" research, although fairly recent, allow identifying the conceptual contours of this emerging field by conducting a review of the theoretical basic frameworks. The primary goal of the survey is to identify major research fields and dynamics in transitions by review the origins of sustainability transition studies in the literature. Then, the second aim is to review the more notable approaches to research and understand transitions (Multi-Level Perspective, Strategic Niche Management, Transition Management, Technological Innovation Systems) by providing a general critique on them and emphasizing the strengths, contributions and potential lines of future research in this field.
- By using social network analysis within a strategic niche management framework, we provide evidence that the architectural structure of the Italian bioplastic producers network offers great opportunities for the development of a technological niche based on waste valorisation. However, there are some weak features of the system, which might compromise the niche development process. These relates to

expectations upon the new technology, which are generally low and, more critically, are low for those agents occupying central positions in the scrutinised network. These findings provide a clear link between the aims, literature review and the case study.

1.3 Thesis structure

The remainder of this thesis is divided into four chapters, plus a final concluding chapter.

Chapter 2 introduces the debate concerning the relationship between environmental regulations and competitiveness, which have emerged since the so-called "Porter Hypothesis" has challenged the traditional trade-off, proposing a new perspective that argues that improved environmental performance, as induced also by environmental regulations, is a potential source of competitive advantage. In the chapter, the main theoretical and empirical contributions of the literature are discussed.

Chapter 3 focuses on the research question Q.2 and provides an additional reason why a win-win situation may emerge within the context of a quality competition framework. The research question is addressed using a duopoly model of vertical product differentiation in which two firms simultaneously choose to produce either a high (environmentally friendly) quality or low quality variant of the good, before engaging in price competition.

Chapter 4 seeks to provide a description of the more important theories and approaches to understand and explain (sustainability) transitions and their related main concepts by reviewing them and providing some critical considerations in order to have a clear idea about the maturation of sustainability transition studies.

Chapter 5 focuses on the research questions Q.4 and investigates the potential development of the bio-waste technological niche and the factors that may hinder the full development of such technological niche. The study is based on a social network analysis whose core unit of analysis is, of course, the social network. In order to identify all the potential members of the Italian bio-waste technological niche of bio-plastic producers, we have adopted a snowball sampling methodology.

Finally, the *Chapter 6* discusses the main results of this thesis.

2. Environmental regulation, and competitiveness: *a literature review*

2.1 Introduction

While the relevance and the impact of environmental regulations in producing environmental benefits is widely known, the discussion on the effects of environmental regulation on industries' competitiveness has been a topic of debate for several years among scholars.

The debate developed in the last two decades extends within a broad range of theoretic questions tended to analyse whether, under what conditions and how exactly environmental concerns and firms' activities are linked to competitiveness. A commonly explored concern is up to what point endogenous and exogenous factors and circumstances influence the relation between firms' environmental performance and their economic outcomes.

Economic literature emphasized that the additional costs due to environmental regulation would have effects on profitability, demand dynamics, innovation, productivity and investment decisions of the touched firms. A first explanation for these effects is given by *Neoclassical Approach.* More specifically, environmental regulations, in achieving the socially optimal environmental protection, might reduce economic firms' profitability and competitiveness, due to constraints on industry behaviour. Therefore, affected firms will lose market share due to higher production costs, industrial sectors will give up producing polluting goods and hence will change the composition of their production, and industries will relocate to territories with less stringent environmental standards (Jenkins, 1998). The *Porter Hypothesis* (Porter and Van der Linde, 1995) has challenged this traditional view, introducing a new perspective based on the assumption that strict environmental regulations may work as "win-win" policies, able to make "dynamic" economic agents exploiting the new stringent environmental regulations, as an opportunity for innovation and thus, gaining a long-term profitability and competitive advantage. The new perspective has stimulated a wide debate on the conditions under which the Porter Hypothesis may emerge. A core part of the debate relies on the linkage between environmental regulations and technological

change, which is recognised as a key determinant that may lead to a positive effect on competitiveness. The last interpretation, the *Resource – Based View* of the firm, takes as fundamental the Porter' s idea and expands the range of resources that firms can rely on. In particular, the contribution provided a theory to explain competitive advantage as an outcome of the development of valuable organizational capabilities, such as continuous innovation, organizational learning and stakeholder integration, associated with a proactive environmental strategy (Hart, 1995). Resource-based studies emphasized as the organizational resources and firms' capabilities are able to link environmental strategies and economic performance.

The present article offers an ample background of the various ways of qualifying and measuring the effects of environmental regulation on market forces outlined in the literature. Furthermore, it summarizes the most recent view on the relationship between environment, economic performance, competitive regulatory strategies, and market dynamics, by providing an overview of the most relevant contributions in the literature, in the context of different theoretical approaches, specifically Neoclassical, Porterian and Managerial (RBV).

The structure of this chapter is as follows. The next section provides an overview of the change in aptitude in considering environmental issues by analysts, policy makers and common people. The second section provides a brief overview of the different environmental instruments. The third sections move on the analysis of the effects of environmental regulation on competitiveness by looking at various theoretical approaches surveyed. Finally, in the last section some concluding remarks are provided.

2.2 Gradual recognition of the environmental issues

Prior to the 1960s, the regulation of polluting substances that could be disposed of into the environment in developed countries was fundamentally a narrow issue. Nevertheless, with the rise in environmental sensitivity in people and, hence, in public opinion during the late 1960s and the early 1970s, governments started adopting national laws for environmental sustainability. As a result, in 1970 in the U.S., for instance, President Richard Nixon founded the Environmental Protection Agency (EPA) by executive order. A few months later, Japanese government did likewise by constituting its Environment Agency under the direct control of the Prime Minister. 1972 was a year of historical significance since Stockholm,

Sweden, was home of the first global United Nations Conference on the Human Environment (Schreurs 2002). Just one year later, European Community presented its environmental protection strategy in its Agenda of environmental action of the European Communities (Hildebrand 2002). This is only a small portion of the many environmental initiatives that were set out during those years. In the light of this new phenomenon, different viewpoints on the influence of the environmental policy on economic performance have emerged.

2.3 Environmental regulation: a brief overview of the instruments

Regulation can be defined generally "to include the full range of legal instruments by which governing institutions, at all levels of government, impose obligations or constraints on private sector behaviour. Constitutions, parliamentary laws, subordinate legislation, decrees, orders, norms licenses, plans, codes and even some forms of administrative guidance can all be considered as regulation" (OECD, 1997). Environmental regulation includes environment-related regulation that considers and impacts the environment (Kemp, 1998).

Often, the discussion on environmental policy instruments is carried out as if there were only two applicable instruments: environmental standards and taxes on emission. However, many dedicated instruments exist with different aims and features. In jargon, environmental policy instruments are often viewed as "marked based instruments" and "command and control instruments". According to Sterner (2003) this kind of classification seems quite poor. In this respect, some environmentalists assert that there are three basic categories of policy instruments nicely labeled as "carrots, sticks and sermons" to epitomize economic incentives, legal instruments and voluntary or soft instruments, respectively (Bemelmans et al. 1998).

Many environmental policy instruments frameworks have been suggested to classify and compare the environmental mechanisms of regulation. One useful typology that relies on World Bank Report 1997 refers only to three major categories: *direct regulation* (command and control), *economic instruments* and *soft instruments*.

Firstly, *direct regulation* includes environmental standards, commands and prohibitions in relation to inputs, processes and outputs. "IPPC Directive" gives a

typical example. It is a standard set by the European Union with the "Integrated Pollution Prevention and Control" Directive (96/61/EC). Such standard requires the issuance of an authorization for all industrial and agricultural activities that have a high pollution potential. This authorization may be granted only if certain environmental conditions are met, to ensure that the companies bear responsibility for preventing and reducing pollution that they may cause. Secondly, *economic instruments* include duties (e.g. taxes, charges), tradable emission permits (e.g. EU Emissions Trading Scheme) and environmental liability. Finally, *soft instruments* include voluntary industry agreements, communication and information measures as well as environmental certification schemes (e.g. ISO 14001, EU Environmental Management and Auditing Scheme (EMAS) or the EU Ecolabel).

Still remains substantial debate about the most successful instrument of environmental regulation to enhance the environmental performance of a sector without leading to a situation of competitive weakness. According to Lopez et al. (2009) direct regulation, for instance, implemented under IPPC directive is generally recognized being effective from the point of view of environmental performance, but it is quite uncertain its effect on industry's competitiveness. Conversely, the effectiveness of the economic instruments, such as tradable permits is broadly accepted in the literature (Requate and Unold, 2000). In general, still remains on one side, the necessity for more empirical evidence on the economic performance of the direct regulation instruments, and on the other side the need to point out the environmental efficiency of economic and soft instruments.

2.4 The theoretical approaches of the environmental regulation

An efficient environmental regulation is needful to successful markets that look with particular attention to issues relating to human health and environmental sustainability. Unregulated markets would be pointless, unfair and not able to deliver what people want: safe, reliable products and a clean environment in which to live and work (Hildebrand, 2002). If on the one hand some environmental mechanisms of regulation (i.e. *environmental standards*) have been recognized as crucial for the environmental performance of a country; on the other hand, their setting pose a relevant question: *Does compliance with stricter environmental regulation weaken an industry's or a country's competitiveness in world markets?*

To this regard economic theory suggests different viewpoints and theories on the link between environmental policies and a firm's environmental and economic performance. The debate developed in the last two decades extends within a broad range of theoretic questions tended to analyse whether, under what conditions and how exactly environmental concerns and firms' activities are linked to competitiveness. A commonly explored concern is up to what point endogenous and exogenous factors and circumstances influence the relation between firms' environmental performance and their economic outcomes.

As mentioned above, it is possible to distinguish between three main viewpoints in the environmental literature:

(1) The *neoclassical approach* of environmental economics: Using the neoclassical model of a profit-maximizing firm with perfect information, neoclassical environmental economists argue that profit-maximizing cleaner technology will be adopted by profit-maximizing firms without requiring a regulatory stimulus: regulation can only act as a constraint on firms. Therefore, neoclassical environmental economists reject the possibility that regulation can generate a "*win-win*" solution, achieving both environmental protection and economic gains.

(2) In contrast to the neoclassical viewpoint, a progressive view arose (*Porterian approach*). The key point was that an enhanced environmental performance is a possible source of competitive advantage, as it might give rise to more well-organized processes, enhancements in factors productivity, reduced costs of compliance to environmental standard and new market openings (Porter, 1991).

(3) Finally, the *'resource-based view'* (RBV) or (*managerial approach*) of the firm came out from the failure of the 'structure conduct performance' paradigm of the industrial organization view of companies, according to which a firm's success/defeat is entirely caused by its external environment. The RBV of the firm suggest a theory to validate the competitive advantage as a result of the development of valuable organizational abilities, such as constant innovation, organizational learning and stakeholder integration, associated with a proactive environmental strategy (Hart, 1995).

A summary of different perspectives of the effects of environmental regulation on firms' competitiveness is shown in Table 1.

Table 1. A comparison among different theoretical approaches

NEOCLASSICAL	PORTERIAN	MANAGERIAL (RBV)
Strict regulation has negative effects on productivity and competitiveness.	Environmental regulation may not only benefit the environment but also the regulated industries by making firms realize otherwise neglected investment opportunities.	Environmental regulation is potentially beneficial for firms only if is accompanied by valuable organizational abilities.

2.4.1 Environmental regulation as an economic restriction (*neoclassical approach*)

The relationship between environmental protection and industrial economic performance has been typically explained in terms of a trade-off between social benefits and private costs. The theory of competitive firms is based on the assumption that the costs are internal to the firm, thus, all the production costs are well-known and considered in the production decision, and firms achieve an equilibrium that maximizes their profits subjects to contractual and technological constraints. If market can work freely, the achieved equilibrium should be the optimal solution for the firm and those firms that fail to perform efficiently would be expected to exit the market. Neoclassical economists emphasize that, in a perfectly competitive economy, prices would give the right signals to firms for optimal investment in R&D and new technologies; so profit-maximizing firms would find opportunities to reduce costs and inefficiencies by themselves, without requiring a regulatory stimulus. Therefore, regulation can only act as a constraint on firms.

However, many production decisions might well impose costs on third parties, the external costs that are not fully reflected in market prices. The typical example is the pollution: a firm may produce at an economically efficient level but may also produce pollution, which is an external cost imposed on other parties. Therefore, according to the traditional paradigm, environmental degradation is a classic case of market failure, where private and public costs in the production of goods diverge. Because the social cost of private polluting activity is not fully reflected in prices,

the price mechanism does not yield the optimal allocation of resources.

From a policy perspective, the solution to environmental problems proposed by neoclassical welfare economist consists in internalizing environmental external costs in the markets. Under this perspective, policy analysis involves choosing appropriate policy instruments that could take, for instance, the form of taxes or pollution standards (Pigou, 1920), or the form of property-rights (Coase, 1966). In this view, the total economic cost becomes the sum of private cost and external cost and the economically efficient allocation of resources is obtained through the integration of externalities in energy price. Therefore, environmental regulations may be justified as measures to adjust prices so that they internalize the environmental costs for achieving the socially optimal environmental protection.

According to neoclassical environmental economists, better environmental performances, promoted by environmental regulations, may benefit society as a whole, but may reduce firms' profitability. In particular, it entails greater production costs and decrease time and money to more profitable activities. This is believed to have effects on firm's economic results. Firms touched by this negative process will lose market share because of higher production costs, the industry will renounce to produce polluting goods by transforming part of its production processes and some firms will move to other countries with less strict environmental regulation. As a result both environmental and economic performance will be affected at global level (Jenkins, 1998). This is particularly significant for those industries where the share of environmental costs in total manufacturing costs is considerably higher than for the manufacturing sector on average. Moreover, some firms operating upstream in the production chain have environmental impacts (and related external and social costs) that are greater with respect to the added value related to their production processes (Clift and Wright, 2000).

Basically, neoclassical view began to spread in the early seventies. The new environmental polices have restricted, actually, the amount of pollution and waste released into the environment by industry. However, opponents of the new pollution control measures, often with vested interests, began to predict that the costs of environmental compliance would have been detrimental for innovations and firms' competitiveness. As a result, this would have had a negative effect on growth rates of environmentally friendly countries. According to Luken (1997),

environmental regulation clearly imposes large direct and indirect costs on the economy, and there is no evidence supporting the carrying out of severer environmental regulation to foster firms' economic performance. Furthermore, burdened by higher compliance expenditures due to a stricter regulation, domestic firms would have had difficulties in competing in worldwide markets (Keller and Levinson 2002). In addition to the capital employed in the pollution control and in other operating costs, there is also an issue regarding the opportunity cost of compliance to the different environmental standards. By spending economic and human capital on pollution abatement and on environmental Research and Development, firms might neglect other investment opportunities (Stewart 1993). Regulation can also increase uncertainty associated with future investments, so that they are postponed. Given that investment budgets are limited, enforced R&D for cleaner technology can have the effect of reduced R&D expenditure in other, more profitable areas, such as a firm's core business (Gray and Shadbegian, 1995). This first group of contributions (Table 2) provides some theoretical arguments aiming at supporting the neoclassic perspective.

Table 2: Theoretical contributions on the neoclassical approach.

Author(S), Years	*Research Question*	*Main Argument*
Jenkins, 1998	The effect of environmental regulation on firms' international competitiveness.	Firms touched by environmental regulation lose market share because of higher production costs and, accordingly, move to other countries with "softer" environmental regulation.
Clift and Wright, 2000	Relationship between environmental impacts and added value along the supply chain.	Firms operating upstream in the production chain have greater environmental impacts and thus, compliance costs than the others. This reduces the management time devoted to pursuing other tasks having effect on firm's competitiveness.
Luken 1997	The effect of environmental regulation on industrial competitiveness of selected industries in developing countries	Environmental regulation clearly imposes large direct and indirect costs on the economy of developing countries, and there is no evidence supporting the carrying out of severer environmental regulation to improve environmental performance.
Keller and Levinson, 2002	The effect of sustaining pollution abatement costs on the investments of domestic firms.	Burdened by higher pollution abatement costs because of a more stringent regulation, domestic firms have difficulties in competing in some foreign markets where the regulation is not so

		strict.
Stewart 1993	The opportunity cost on environmental regulation	By devoting time and money on pollution abatement and on environmental Research and Development, firms may neglect other investment opportunities.
Gray and Shadbegian, 1995	The effect of environmental regulation on investment timing and technology choice.	Firms' investment budgets are limited; therefore, enforced R&D for cleaner technology can have the effect of reduced R&D expenditure in other, more profitable areas. Moreover, this may lead to a situation of internal uncertainty associated with future investments, so that they are postponed.

Most of the empirical studies aimed at endorsing neoclassical view of environmental regulation have come to light mainly during the U.S economic crisis of the seventies. The economic downturn with consequent reduced production, registered in the U.S. in the 1970s, brought various economists to "speculate" that environmental regulation was, at least in part, responsible (Gray 1987, Gollop and Roberts 1983; Barbera and McConnell 1990). For example, in the United States, the Clean Air Act Amendments[1] were believed to have caused relevant problems on: firms' economic performance; labour productivity; endowment of capital; firm's location decisions; and Gross Natural Product (GNP) (Greenstone, 2002).

Different approaches have been considered in the literature in order to assess the impact of the environmental regulation on firms' economic performance. The three most common approaches involve growth accounting, macroeconomic general equilibrium modelling, and econometric estimation. A clear illustration of the growth accounting methodology is given in Denison (1979), who measures changes in total factor productivity and evaluates the increasing economic cost caused by environmental regulation post 1967. Denison states that environmental regulation post 1967 gave rise to between 13-20% of the productivity loss during the period of U.S. crisis.

Using a general equilibrium macro-model, Jorgenson and Wilcoxen (1990) model the U.S. economy including a long-term growth component with and without

[1] The Clean Air Act is a United States federal law designed to control air pollution on a national level. It requires the Environmental Protection Agency (EPA) to develop and enforce regulations to protect the public from airborne contaminants known to be hazardous to human health. The 1963 version of the legislation established a research program, expanded in 1967. Major amendments to the law, requiring regulatory controls for air pollution, passed in 1970, 1977 and 1990.

environmental regulation and find that in the absence of all environmental regulation, the capital stock would have been almost 3.8% higher and GNP would have been more than 2.5% higher. They separate out the effects of the removal of environmental operating and maintenance costs (responsible for 0.544% reduction in the capital stock and 0.728% reduction in GNP, respectively) from the economy and abatement capital expenditures (2.266% and 1.290%) in order to find differences in types of environmental regulation. The authors denote large sectorial effects, especially in chemicals, petroleum refining, and primary metals.

Moreover, there are numerous econometric analyses that study the correlation between environmental regulation and economic performance. In particular, Gray (1987), who investigates the effect of the Occupational Safety and Health Administration (OSHA) and Environmental Protection Agency (EPA) regulations on productivity, found a large negative relationship between such regulation and productivity growth. He estimates that about 30% of the decrease in productivity in manufacturing during the 1970's might be due to environmental regulation. Gollop and Roberts (1983), carried out a study on fossil fuelled electric power plants and estimate that 44% of the productivity slowdown was attributable to regulation in this sector between 1973 and 1979. Likewise, Gray and Shadbegian (2003) explore the relationship between economic performance and environmental regulations for plants in three U.S. industries. When a measure of environmental regulations is given by compliance costs, they show a negative relationship. Though, when other commonly used measures of environmental regulation are taken into account, like compliance status or the number of inspections by the regulatory agency, the estimated coefficients result to be not significant. Furthermore, Barbera and McConnell (1986, 1990), find in two separate papers that average capital and labour productivity reduced because of environmental regulation during the seventies and that the entity of results diverges across sectors analysed.

A summary of these empirical studies is shown in the Table 3.

Table 3: Empirical studies on the neoclassical approach.

Author(S), Years	*Research Question*	*Main Results*
Deninson, 1979	Accounting for slower growth in U.S. during seventies.	Environmental regulation post 1967 led to an increase between 13-20% of the productivity loss during the period of

		U.S. crisis
Jorgenson and Wilcoxen, 1990	A general equilibrium macro – model for evaluating the influence of environmental regulation on U.S. economic growth.	They found out that in the absence of all environmental regulation, the capital stock would have been in average 3.792% higher and GNP would have been more than 2.5% higher.
Gray, 1987	The effect of OSHA and EPA regulation on productivity of manufacturing industry in U.S.	This study finds a large negative relationship between such regulation and productivity growth. About 30% of productivity decline may be attributed to OSHA and EPA regulation
Gollop and Roberts, 1983	The effect of environmental regulations on productivity growth on fossil fuelled electric power generation	They estimate that 44% of the loss in productivity was due to environmental regulation (Clean Air Act) in this sector between 1973 and 1979.
Gray and Shadbegian, 2003	Relationship between economic performance and environmental regulations for plants in different U.S. industries	More strict air and water regulations have a significant impact on the technological choices of paper mills in the U.S. when compliance costs are considered the only measure of environmental regulations.
Barbera and McConnell 1986, 1990.	A factor demand approach to evaluate the effect of environmental regulation on labour and capital productivity.	They estimate a system of demand equations and find that abatement requirements have reduced capital and labour productivity in several industries but the entity of results may diverge across sectors considered.

In general, these studies provide a consistent finding of small, negative effects of regulation on economic performance. The literature indicates that the effects of regulation on productivity (measured as either total factor productivity, or labour productivity, or capital productivity, etc.) might vary strongly across industrial sectors, and that different measures of productivity may lead to slightly different results. Moreover, pollution intensive industries that bear the burden of environmental regulation show the major negative impact on their economic performance.

In conclusion, the traditional perspective emphasizes the role of environmental regulations as measures to correct for environmental degradation, which is depicted as a typical case of market failure; but it rejects the possibility that regulations can achieve both environmental protection and economic gains.

2.4.2 Environmental regulation as a competitive advantage for affected firms (*porterian approach*)

Since the early nineties, the neoclassical theory, and the vision that it has traditionally supplied the negative effects of the application of environmental

policies on the competitive dynamics, have been put seriously in question by scholars and research groups who opposed empirical evidence in contrast to the assumptions and considerations mentioned above. As opposed to the neoclassical "*traditional*" perspective, a "*revisionist*" perspective, commonly identified with the Porter Hypothesis, argues that improved environmental performance, as induced by environmental regulations, is a potential source of competitive advantage, leading to productivity growth, lower costs of compliance to regulations and creating new business opportunities.

Porter's Idea

In the early nineties some researchers tried to challenge the empirical and theoretical contributions that stated how environmental regulation hurt firms' economic performance. These scholars developed an absolutely opposed view to the neo-classical one, which stemmed by (and was largely identified with) the theoretical contribution of Michael Porter. The basic argument of the Porter Hypothesis was initially formulated in one-page article (Porter 1991) and was successively elaborated on Porter and van der Linde (1995) as well as Esty and Porter (1998). Porter (1991) states that "*strict environmental regulation do not inevitably hinder competitive advantage against foreign rivals* (p. 96)*"*. This is the basic idea of the Porter Hypothesis. The starting point of the analysis is that environmental regulations can stimulate firms to find more efficient ways to produce, and that such innovations may partially (or even more, fully) offset the static private adaption costs, thus boosting the competitiveness of regulated firms through improved technical efficiency. Therefore, by pushing firms to develop and adopt eco-innovations, environmental regulation may improve the natural environment, on the one hand, and the firms' competitiveness, on the other. In other words, the Porter Hypothesis proposes a win-win situation as a consequence of environmental regulation, in the sense that the environmental policies might give rise to a situation in which both social welfare and private net benefits of firms can increase. On the one side, the reason for which strict environmental regulation might rise the social welfare is widely accepted among the environmental economists: in case of negative externalities, the marginal social cost is greater than the marginal private cost, being the difference the marginal external cost. Therefore, the optimal output is lower than the output produced in fact in the

industry: namely, in presence of negative externalities, firms produce too much output. In this context, environmental regulations and related instruments (taxes, emission permits, environmental standards) result to be a valuable tool to revise this inefficiency, i.e. to correct the market failure caused by a negative environmental externality. On the other side, the reason why environmental policy may enhance the private welfare is not so easily understandable. In this respect, the Porter Hypothesis states that environmental regulations is able to foster firms to develop eco-innovations that might partially or even more then fully offset the static private costs of compliance. Accordingly, a severer environmental regulation might enhance the economic performance of regulated firms through a better technical efficiency. As said by Porter and van der Linde: *"properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them"* (p. 98). Namely, environmental policies, if well designed, might give rise to sustainable innovations and these innovations could create profits for firms.

The concept of offsets is fundamental in Porter's preposition, because innovation cannot always entirely counterbalance the cost of compliance, particularly in the short term, but *"the net cost of compliance can fall with stringency and may even turn into a net benefit"*. Thus, the Porter's idea calls into question the traditional assumption that additional environmental regulations will always encounter additional costs hurting to the competitive position of the touched firms, but it captures the idea that environmental regulation could enhance firms' efficiency and thus, their economic performance, when properly designed. Namely, regulations might not only give rise to a reduction of the pollution abatement cost but could also generate innovation opportunities which can eventually provide an absolute advantage over those not facing such regulations. The main causal links of the Porter Hypothesis are shown in the following diagram from Ambec et al. (2010) (Figure 1):

Figure 1. The Porter Hypothesis

Source: Ambec et al. (2010)

2.4.2.1 Theoretical models analysing the porter hypothesis

Several theoretical analyses have been proposed in order to assess Porter's statements highlighting the reliability or the limitations of the hypothesis.

Sinclair-Desgagnè and Gabel (1999) offer a theoretical contribution in which they propose for environmental regulation to be considered "*an industrial policy instrument aimed at increasing the competitiveness of firms, the underlying rationale for this statement being that well-designed environmental regulation could force firms to seek innovations that would turn out to be both privately and socially profitable"*. Their perspective is that the interaction between environmental regulation and the right allocation of firms' resources is complicated. The most important determinant in achieving economic performance in a context of environmental regulation is the firm's ability to readily react to the regulation by developing new technologies, production processes and products. It is crucial, in this respect, the institutional context in which firms operate since it should provide the right supportive policies that would allow firms to make possible the opportune technological changes.

Lankoski (2000) proposes a model with vertical product differentiation (degree to which products are perceived differently by buyers) in a duopoly market. Environmental performance can be viewed as a quality variable and as the main differentiation between firms, one supplying a product with high environmental performance and another supplying a product with low. Moreover, consumers have a willingness to pay for environmental performance greater than zero. Lankoski (2000) find that the relation between environmental regulation and competitiveness may diverge where firms' choices are not independent. Hence, the obtained environmental performance might not result socially optimal and require a

regulatory intervention. This finding is a clear indication of the importance of other market circumstances for the validity of the Porter hypothesis. In fact, the hypothesis might critically rely on particular circumstances, like e.g. the industry's market structure.

Xepapadeas and Zeeuw (1999) develop a model that suggests that the trade-off between environment and competitiveness can be resolved as suggested by Porter, when "*downsizing and modernization of firms subject to environmental policy will increase average productivity and will have positive effects on the marginal decrease of profits and environmental damage*". They find that an increasing production costs due to stricter environmental regulations give rise to a capital stock restructuring that allow enhancement in the productivity of firms. Therefore the effect is twofold: on the one side, stricter environmental regulations (viewed in terms of an increase in an emission tax) leads to a reduction of the amount of equipment and thus, a reduction of firm size, (downsizing effect); on the other side a (modernization effect) appears. In particular, it reduces the capital stock's average age speeding up the removal and substitution of the older endowments of firms. Hence, the model shows that the additional cost of stricter environmental regulation is more than offset by the "downsizing effect" (leading to upward pressure on prices), and the "modernization effect" (increasing the capital stock productivity).

Mohr (2002) starting from Xepapadeas and de Zeeuw (1999) model and assuming also external economies of scale (i.e. spillover) in production provides a more complete scenario. Based on a general equilibrium model of a closed economy with many agents, constant population, perfect information and an environmental externality he finds that while environmental regulation increases, at the same time, productivity and welfare, a policy that implies this effect is not automatically optimal. Mohr (2002) shows that in his model, environmental regulation rises the economic and environmental performance if (i) a new and unexploited technology is available, that is more effective than the one currently used, and (ii) if environmental regulation fosters the new but more effective technology. As a consequence, *"Porter's hypothesis is a plausible outcome if one allows for the possibility of technological change with external economies of scale)"* (Mohr, 2002: 164).

Ambec and Barla (2002) model the idea of Porter and van der Linde that regulation generates external pressure in order to offset the initial organizational

inertia. A model of renegotiation provides this. Following Porter, it is supposed that less polluting technologies are also more productive. There is a problem of asymmetric information within firm: managers have private information about the cost of new technologies. The firm must therefore offer rents to reward truthful report of high productivity. The possibilities of renegotiation prevent the firm from reducing these rents by distorting production. In this context, regulation may help because, unlike the firm, the regulator can commit to distort production to the socially efficient level so that reporting unproductive and polluting technologies becomes less attractive. Likewise, because of the separation of ownership and management organizational failures may occur. Therefore, according to Kennedy (1995), decisions of a firm may not be guided by the maximization of its expected profits, but by some other objectives of managers. Managers may be more risk averse than owners and also more myopic since their revenue depends very much on current performance and they stay at a firm only for a limited period of time (Ambec and Barla 2006). These kinds of failures have the effect that profitable investments in R&D might not be undertaken without some external incentive, which in turn may be provided by environmental policies. Hence, by increasing the return on R&D investments, environmental regulations bring managers closer to the optimal investment decision (Kennedy, 1995).

According to Greaker (2003), socially desirable innovations might not be implemented since the private returns to R&D are different (smaller) from the social ones. One possible motivation is given by spillovers as supposed also by Mohr (2002). In particular, if firms are driven to innovate they all benefit from positive externalities and will be better off than before. Therefore, policy makers should be ready at introducing a sufficiently innovative environmental policy.

Andrè et al. (2009) show that environmental regulation may help to overcome firms' coordination failures. They take into account a duopoly model with vertically differentiated products on environmental quality. They find that environmental regulations help firms to coordinate on a Pareto superior equilibrium choice of environmental quality.

To sum up, there is conspicuous evidence about theoretical arguments of the Porter hypothesis, according to which, a stringent environmental regulations lead to a long-run competitive advantage for firms.

Table 4 below list the group of theoretical contributions considered on the Porter's hypothesis:

Table 4: Theoretical contributions on the Porter Hypothesis.

Author(S), Years	*Research Question*	*Main Argument*
Sinclair-Desgagnè and Gabel, 1999	The interaction between environmental regulation and the right allocation of firms' resources	The relation is complex. Two are the main determinants in achieving economic performance in a context of environmental regulation: the firm's ability in reacting to the regulation (innovation); the institutional context in which firms operate.
Lankoski, 2000	The relation between environmental regulation and competitiveness analysed through a model of vertical product differentiation in a duopoly market	Environmental performance might not result socially optimal and require a regulatory intervention when firms' choices are not independent. This finding is a clear indication of the importance of other market circumstances (i.e. the industry's market structure) for the validity of the Porter hypothesis.
Xepapadeas and Zeeuw, 1999	A model analysing the trade-off between environment and competitiveness in accordance with Porter Hypothesis.	Environmental regulations give rise to two main effects: reduction of the amount of firm's equipment (downsizing); introduction of new technologies (modernization). These would give rise to a capital stock restructuring that allow enhancement in the productivity of firms.
Mohr, 2002	He expands the Xepapadeas and de Zeeuw model (1999) by assuming also external economies of scale.	Regulation increases economic performance if a new technology is available and if environmental regulation encourages this technology.
Ambec and Barla, 2002	Asymmetric information within firm: managers have private information about the cost of new technologies.	These kinds of failures have the effect that profitable investments in R&D might not be undertaken without some external incentive, which in turn may be provided by environmental policies.
Greaker, 2003	Technological spillovers in the upstream pollution abatement industry.	Environmental regulations might help to mitigate the underinvestment problem to the benefit of the downstream firm.
André et al., 2009	Market power with vertically differentiated products on environmental quality.	Environmental regulations help firms coordinate on a Pareto superior equilibrium choice of environmental quality.

2.4.2.2 Empirical analysis of the porter hypothesis

Many researchers tried to assess the Porter hypothesis empirically. First of all, Porter and van der Linde proposed their contribution basically by focusing on case studies, on the basis of the argument that these *"...are the only vehicle currently available to measure compliance costs and both direct and indirect innovation benefits"* (1995: 101) In this respect, they mention numerous case studies as evidence for the validation of the Porter hypothesis. This pertains, for instance, the cell battery, printing ink, electronics manufacturing, pulp and paper and refrigerator industries. As stated by the authors, case study evidence supports several mechanisms through which the Porter hypothesis appears to be working.

Two approaches are emerging from this empirical literature: the first aims ad studying the "*weak*" version of the Porter Hypothesis, namely, the relation between the strictness of environmental regulation and the innovation process; the second intends to analyse the impact of environmental regulation on the firms' economic performance.

With regard to the first approach, Jaffe and Palmer (1997) evaluate the correlation between total R&D expenditures and pollution abatement costs with particular focus on the U.S., and limited to manufacturing firms. They show a positive relation with R&D expenditures (an increase of 0.15% in R&D expenditures corresponding to a pollution abatement cost increase of 1%), but no statistically significant with the number of patents. However, Brunnermeier and Cohen (2003) find out a concrete link between mechanisms of environmental policy and successful environmental U.S. patents. Moreover, Popp (2006) offers proof that the introduction of an environmental standard on sulphur dioxide (SO_2) in the US, and on nitrogen dioxides (NO_X) in Germany and Japan, gave rise to an important increase in the number of relevant patents. Popp finds that inventors respond to domestic regulatory pressures supporting the argument that a positive relationship between environmental regulations and firm's R&D expenditures occurs. In addition, Arimura et al. (2007) use a bivariate Probit model to examine the linkage between the stringency of environmental policies and environmental R&D, which results in a positive and significant relationship between the overall perceived environmental regulation stringency and the probability to run an environmental R&D program. Finally, Leiter et al. (2009), by taking into account data on European industry over a period of time between 1995 and 2005, have shown as

environmental strictness has a positive (but decreasing with time) effect on investment decisions. This strand of studies is illustrated in Table 5.

Table 5: Empirical studies on the Porter Hypothesis

First approach: Impact of Environmental Regulations on Innovation Process

Author (S), Years	***Research Question***	***Main Results***
Jaffe and Palmer, 1997	Correlation between total R&D expenditures and pollution abatement costs in U.S manufacturing industry (1973-1991).	R&D significantly increases with Environmental regulation (elasticity: +0.15). No significant impact of Environmental regulation on number of patents.
Brunnermeier and Cohen, 2003	Correlation between total R&D expenditures and pollution abatement costs in U.S manufacturing industry (1983-1992).	Small but significant impact of pollution operating cost on number of patents if it is not considered as a proxy for innovation R&D investments but only and number of successful patent
Popp, 2006	Impact of SO_2 (U.S.) and NO_X (Germany and Japan) Environmental Regulations on patenting and patent citations.	The introduction of an environmental standard on sulphur dioxide (SO_2) in the U.S., and on nitrogen dioxides (NO_X) in Germany and Japan, gave rise to an important increase in the number of relevant patents.
Arimura et al., 2007	Bivariate probit model with environmental R&D dummy regressed on various measures of environmental policy (perceived stringency, standards, taxes),	The perceived environmental regulation stringency has a positive and significant impact on the probability to run an environmental R&D program and the type of regulation (standard or tax) has no significant effects on environmental R&D
Leiter et al., 2009	Correlation between total R&D expenditures and pollution abatement costs in seven OECD countries (1995 – 2005).	Environmental regulation has a valuable (but decreasing with time) effect on investment decisions.

The second empirical approach evaluates the effect of environmental policies on the firm's economic performance often measured by its productivity.

For instance, Berman and Bui (2001) show that the refineries situated in Los Angeles and surrounding area experienced higher production efficiency in comparison with other U.S. refineries, although a stricter air pollution regulation in this area. Analogously, Alpay et al. (2002) find that the production efficiency of the Mexican food-processing industry is positively and directly related with the intensity of environmental regulation. Hence, they indicate that a stricter regulation is not disadvantageous for firm's productivity, but rather it is advisable. Moreover,

Murty and Kumar (2003) investigate the impact of environmental standards on the productivity of 92 firms in 12 water-polluting industries in India over a four-years time period (1996-1999). The investigation relied on simultaneous estimation of the relation between production inefficiency and environmental regulation. Their findings show how the greater the firms' compliance with the standards (and consequently, the smaller the average wastewater output), the higher the production efficiency of the firm – hence giving support to the Porter hypothesis. Finally, Triebswetter et al. (2005) study whether German industrial plants experienced a negative effect on productivity due to stricter environmental regulation. They find out that the abatement initiatives was no detrimental for the core business, for two main reasons: first, environmental intensity is considered negligible in the estimation compared with other competitive pressures, second, the compliance costs, at least in two of the case studies, are quite low.

This second strand of empirical studies on the Porter hypothesis is summarized in Table 6.

Table 6: Empirical studies on the Porter Hypothesis

Second approach: Impact of Environmental Regulations on Productivity

Author (S), Years	***Research Question***	***Main Results***
Berman and Bui, 2001	Comparison of total factor productivity of California South Coast refineries (submitted to stricter air pollution regulations) with other U.S. refineries. Data (1987 – 1995)	Stricter regulations imply higher abatement costs; however, these investments appear to increase productivity.
Alpay et al., 2002	Estimation of a profit function that includes pollution abatement expenditures (US) and inspection frequency (Mexico) as proxies for environmental regulation.	Environmental regulation has a negligible effect on profits but a positive effect on productivity for Mexican food-processing industry.
Murty and Kumar, 2003	Simultaneous estimation of the relation between production inefficiency and environmental regulation in Indian water pollution industry (1996 – 1999)	Their finding shows as the greater is firms' compliance with the standards, and the lesser is the average wastewater output, the better is the production efficiency of the firm.
Triebswetter et al., 2005	Correlation between the production efficiency and pollution abatement costs in German industrial plants (1990- 2002).	ERs have a significantly positive impact on productivity growth rate, especially in the sectors highly exposed to outside competition.

In conclusion, the survey of empirical studies assessing the Porter hypothesis show that two approaches need to be considered. These regard the relation between

the strictness of environmental regulation and the innovation process and the impact of environmental regulation on the firms' economic performance. On the basis of the approaches taken into account the intensity of results may differ. However, the interpretation of such results from empirical studies, indicate overall a positive relation between environmental regulation and competitiveness.

2.4.3 Managerial approach (RBV)

The neoclassical view among scholars regarding the effect of environmental regulation on firms' competitiveness is that it comes as an additional cost imposed on firms, which may lead to unproductive investment and erode their economic performance. The Porter hypothesis has challenged this traditional view, introducing a new perspective based on the argument that strict environmental regulations may improve firms' efficiency and ensure them an international competitive advantage. However, authors who supported or criticized both approaches have often analysed the link between environmental policies and economic performance taking into account one or a few indicators of a firm's environmental and economic performance, without considering the underlying organizational variables that could affect this relationship. Conversely, the RBV of the firm provided a theory to explain competitive advantage as an outcome of the development of valuable organizational capabilities, such as continuous innovation, organizational learning and stakeholder integration, associated with a proactive environmental strategy (Hart, 1995). Resource-based studies emphasized as the organizational resources and firms' capabilities are able to link environmental strategies and economic performance. For instance, Christmann (2000) suggest that managerial organization concurred to cost advantage when a firm comply with environmental regulation. RBV takes as fundamental the Porter' s idea and expands the range of resources that firms can rely on. This approach redefines the analysis of how environmental policy affects economic performance by focusing, on the one hand, on firm's productivity as the key 'outcome' variable, and on the other hand, by unequivocally recognizing the relevance of endogenous factors, such as management, knows how, corporate culture, reputation and so on (Hall, 1992). This may help to explain, for example, why two similar firms (in terms of physical assets, technologies, and human skills) subject to identical external pressure might develop different strategies and mature a discrepancy in terms of competitive

advantage.

Initial contributions of the RBV in the assessment of the effect of environmental policies and related strategies on firm's economic performance focused essentially on the analysis of firms' internal dynamics purely from the managerial standpoint (explicit and tacit capabilities) (Hart, 1995). More recently, Aragón-Correa and Sharma (2003) integrated perspectives from the literature on contingency, dynamic capabilities and the natural resource-based view of the firm to suggest how organizations of the general competitive environment of a firm affect the development of a dynamic, proactive corporate strategy for managing the natural environment interface of the business. Therefore, while some empirical investigations have attempted to gauge the relationship between the existence of environmental regulation and economic performance of firms that comply with them, academics from the management sciences have provided corporate environmental strategies in case studies (Maxwell et al. 1997). They find confirmation of firms that have well-converted environmental standards into opportunities for business development. Table (7) provides a synthetic description of some of the key theoretical contribution on the effect of environmental policies and related strategies on firm's economic performance focusing essentially on the firms' internal dynamics.

Table 7: Theoretical contributions on the Managerial Approach

Author(S), Years	*Research Question*	*Main Argument*
Hart, 1995	The importance of RBV theory in explaining firm's competitive advantage.	RBV of the firm provided a theory to explain how organizational resources, like a proactive management, and firms' capabilities are able to link environmental strategies and economic performance
Christmann, 2000	The role of management for a better firm's economic performance.	Managerial organization is one of the most important factor which allow firms to achieve competitiveness in complying with environmental regulation
Hall, 1992	How environmental regulation influence economic performance according to RBV.	RBV enlarges the analysis of how environmental policy effects economic performance by focusing, on one hand, on firm's productivity and considering, at the same time, the relevance of endogenous factors, such as management, knows how, corporate

		culture, reputation and so on.
Aragón-Correa and Sharma, 2003	A dynamic, proactive corporate strategy for managing the natural environment in a context of firm's competitiveness.	They integrate the managerial perspective, by emphasising how dynamic capabilities of a firm result to be fundamental for an optimal corporate strategy. Moreover they identify some issues concerning uncertainty, complexity, and risk aversion which moderate the relationship between the dynamic capability of a proactive environmental strategy and competitive advantage.
Maxwell et al., 1997	Survey on the relation between corporate environmental strategy and economic performance.	They find confirmation of firms that have well-converted environmental regulation into opportunities for business development (cost saving, product diversification, personnel management etc.).

Some of the most usual corporate strategies refer to the following general categories: cost saving, product diversification, risk management, personnel management, reputation and competitive environmental strategies. The following clarifies every category:

1. *Cost saving*: the existence of environmental standards that must be met increases the cost of pollution which comes from the production processes; therefore, firms have one more reason to moderate resource consumption in the first place but also energy conservation and waste minimization are common examples. Life-cycle assessment measuring a product or process environmental impacts and resource consumption at each step of its life was employed to recognize where to intervene in order to achieve resource and fee savings (Nielsen and Wenzel 2002).

2. *Product diversification*: firms in their organizational activity pay particularly attention to the environmentally related characters of their products in managing and advertising them. Hence, depending on consumer demand for these green attributes, the products may require a significant price premium. As Reinhardt (1999) reports, Patagonia (Californian clothing company), has selected a loyal customers' base sensitive to its commitment to environmental causes and hence willing to pay more for its products.

3. *Risk management*: even if not demanded explicitly by any standard, firms might adopt practices to lower their exposure to the risk. Some strategies comprise implementing formal environmental management systems or substituting less toxic

compounds in place of more harmful ones. As Ashford (2000) observes, although not demanded by law, chemical companies usually carry out short-run toxicity tests on new chemicals as a way of preventively dealing with possible risks. Obviously, the early testing costs are significantly less than the potential liability and reputational costs encountered if a substance were found to be dangerous after an extensive use.

4. *Personnel management*: a relatively neglected area in the literature is whether the adoption of environmental standards improves human resource management. In this respect, the multinational corporation Dole Food Co. Inc. reported that the 'key benefits' of adopting environmental management systems include strong employee motivation and loyalty, which translates into, reduced absenteeism and improved productivity. Among the several dimensions of human resource management likely to be affected by the adoption of environmental-related standards, recruitment is an excellent candidate to be studied. Hence, Grolleau et al. (2011) carried out a research in order to investigate whether recruitment is enhanced when a firm has adopted environmental standards. Their findings show that firm's environmental commitment is important for a good personnel management. It is an important attribute for job seekers especially when applicants can compare and rank firms. Hence, companies that are socially or environmentally proactive have a concrete interest in communicating their commitments to potential candidates especially in sectors where recruitment is a sensitive issue.

5. *Reputation and labour productivity:* in adopting an environmental standard, a firm sends a signal to all stakeholders about its improved environmental performance. This can give rise to an enhanced organizational reputation that has a positive effect on workers. As Ambec and Lanoie stated: "*people who feel proud of the company for which they work not only perform better on the job, but also become ambassadors for the company with their friends and relatives, enhancing goodwill and leading to a virtuous circle of good reputation"* (2008: 57). Hence the authors, in this study hypothesize that the adoption of environmental standards is associated with greater labour productivity. Beside the first fundamental assumption, the authors develop two additional hypotheses with regard to the organizational changes connected to the adoption of environmental standards. Most of them, such as ISO 14001 require an implementation of an environmental management system inside the firm that entails proper training for workers and an

interpersonal communication within the organization. Based on this reasoning the authors formulate such assumptions as mechanisms through which an environmental standard lead to greater labour productivity.

6. Competitive regulatory strategy rely on the assumption that environmental mechanism of regulation may be mitigated or addressed from some endogenous variables, namely, firms may be able to condition environmental standard setting process. The old and conventional view in the environmental literature can be summed up well through a sentence: *"If the law says that the firm can emit up to 500 tons of glop per year, it has no reason to spend a penny to reduce its discharges to 499"* (Blinder, 1987 quoted in Arora and Gangopadhyay, 1995). Under this approach, once an environmental standard has been set each firm should conform to the minimum level that is legally required without investing extra money in the reduction of pollutants of production processes. An interesting argument is the effective firms compliance to environmental standards with regard to managerial strategies. In order to obtain a competitive advantage a managerial strategy might be to "capture regulation". In 1971 Stigler concentrates his theoretical analysis on companies that are able to attain friendly regulation in return of votes or resources, but there is another version why "*regulatory capture"* might arise. Environmental standard setting organizations have an innate tendency regarding confident technology claims given their interest in realizing environmental progress. The openness of technology vendors, and perhaps to a lesser extent, the first-mover firms, enhances a regulator's optimism in the reachability of more stringent regulations. Given the large uncertainties in technology enhancements and environmental effects, regulators are certainly interested in obtaining clear verification that endorses its perspective for a regulation. Therefore, it is relevant for a regulator to discriminate from real claims of public benefit and a mere attempt in order to achieve a rent-seeking. Namely, according to Winter and May (2002) a firm that desires to enhance demand for its products or technology using regulation would need to realistically persuade government regulators that an environmental standard suggested truly does progress public welfare. Furthermore, because of issues concerning unemployment and market concentration, a firm might also have to demonstrate that the environmental regulation does not entail relevant distributional effects. Additionally, in order to capture regulatory companies might align themselves with well-known

environmental NGOs or citizen groups to convince the public, and perhaps more importantly, regulators, that their strategy is actually environmentally beneficial (Winter and May, 2002). Conversely, the regulated industry might have an incentive to moderate their technological enhancement to prevent greater regulator expectations and therefore, a stricter environmental policy. Regulators are able to perceive firm environmental performance progress over time adapting environmental regulation on the basis of new information. This could give rise to strategic conduct by firms. Therefore, firms behave cautiously and conservatively in performing their environmentally proactive actions and, in the worst case, they might deliberately obscure or delay enhancements on environmental R&D (Fouts and Russo 1997). As a consequence if no firm is able to meet the planned environmental standards then regulators are inducted indirectly to weaken or postpone standards.

7. Long-term environmental strategy: Companies, as we already said, may proactively seek or support regulation based on their ability to meet standard at lower costs or with better technology than their competitors. However, managers should realize that the adoption of a few environmental practices or a proactive environmental approach for a limited period of time will not necessarily lead to competitive advantage. Rather, it is important to adopt a long-term, consistent strategy that promotes: continuous interfacing with all stakeholders, so as to reduce the complexity and state uncertainty of conflicting environmental issues; development of managerial and organizational knowledge for managing the continuous emerging issues; and generation of continuous improvement and innovation. Organizations that adopt a consistently proactive approach will develop a dynamic capability through which they will obtain a competitive advantage (Aragón‐Correa and Sharma 2003). The above contributions are summarized in Table (8).

Table 8: Corporate environmental strategies enhancing economic performance

Author (S), Years	*Research Question*	*Main Argument*
Nielsen and Wenzel, 2002	Environmental regulation and cost saving.	If on one hand the compliance with the environmental regulation increases the production costs of firms, on the other hand it has been shown that firms have one more reason to moderate resource consumption in the first place but also energy conservation and waste minimization are common example.

Reinhardt, 1999	Product diversification from environmental compliance.	Firm's compliance with higher environmental standard allows them to produce environmentally better products. Hence, Patagonia (Californian clothing company), has selected a loyal customer base sensitive to its commitment to environmental causes and hence willing to pay more for its products
Ashford, 2000	Corporate environmental strategies as risk management.	Firms might adopt practices to lower their exposure to the risk. As it is shown chemical companies usually carry out short-run toxicity tests on new chemicals as a way of preventively dealing with possible risks. Obviously, the early testing costs are significantly less than the costs encountered if a substance were found to be dangerous after an extensive use.
Grolleau et al., 2011	Environmental regulation and personnel management	Their findings show that firm's environmental commitment is important for a good personnel management. It is an important attribute for job seekers especially when applicants can compare and rank firms. Hence, companies that are socially or environmentally proactive have a concrete interest in communicating their commitments to potential candidates especially in sectors where recruitment is a sensitive issue.
Ambec and Lanoie, 2008	Environmental regulation reputation and labour productivity.	In adopting an environmental standard, a firm sends a signal to all stakeholders about its improved environmental performance gaining reputation that has a positive effect on workers. Moreover, the implementation of an environmental management system entails proper training for workers and an interpersonal communication within the organization leading to a higher labour productivity.
Stafford et al., 2000	Corporate environmental strategies to "capture regulation"	In order to capture regulation companies might align themselves with well-known environmental NGOs or citizen groups to convince the public, and perhaps more importantly, regulators, that their strategy is actually environmentally beneficial.
Gersbach, 2002	Corporate environmental strategies to "moderate regulation"	Firms might behave cautiously and conservatively in performing their environmentally actions or they may deliberately obscure or delay enhancements on environmental R&D in order to weaken or postpone environmental standards

In conclusion, the RBV perspective recognizes the role of a firm's resources in its development of a proactive environmental strategy. These resources include technology, managerial skills, attitudes and those capabilities to exploit opportunities from pollution prevention, continuous innovation and stakeholder

integration. Therefore, according to Klassen and Whybark (1999) environmental strategies in the form of investments in pollution prevention technologies only give rise to environmental and competitive enhancements when they are accompanied with the development of certain and proactive managerial strategy.

2.5 Conclusive remarks

Within the debate on the relationship between environmental regulations and competitiveness, a key concern regards the existence of a "trade-off" vs. "win-win" results, between environmental regulations and firm's economic performance. In contrast with the neoclassical perspective, that emphasizes a negative relationship between environmental regulations and competitiveness, supported by some empirical studies, increasing empirical evidence has reinforced the argument that, in some cases, there are positive effects of environmental regulations on firm's economic performance, and the entity of this effects might be due to the development of some valuable organizational capabilities within firms.

This chapter has provided an overview of the key theoretical and empirical insights on the link between environmental policies and environmental and competitiveness performance by taking into account three main hypothetical viewpoints in the environmental literature: Neoclassical, Porterian and Managerial.

The present review of the literature shows that the available empirical evidence does not reveal that any strand of research has succeeded over the others, as no unique relationship has yet prevailed in the literature or empirical studies. In particular, the relationship might vary depending on the source of the regulation, its form and the environmental assets it is seeking to protect. Moreover, it may also vary depending on the characteristics of the businesses and sectors concerned (e.g. market power may confer only to some businesses the ability to pass on any increased costs from regulation to the consumer). Taking account of these factors in the methods of assessment may be critical in understanding the exact nature of the relationship between environmental regulation and competitiveness.

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3. Environmental standards and firms' competitiveness: *a theoretical analysis*

3.1 Introduction

Neoclassical economic literature emphasized that stricter environmental regulation always entails additional costs having effects on profitability, demand dynamics, innovation, productivity and investment decisions of the touched firms. Porter (1991, 1995) has challenged this traditional view asserting just the opposite. The main idea behind Porter reasoning is that firms might be not conscious of certain investments opportunities. In particular, more stringent environmental regulations may generate as "win-win" solution, able to make "dynamic" economic agents capable of exploiting such opportunities for innovation and thus, gaining a long-term profitability and competitive advantage. This perspective is now generally known as the Porter Hypothesis.

In this chapter it is provided an additional explanation why a win-win situation could emerge in a framework of vertical product differentiation and full information. The economic intuition at the basis of our idea is the following: firms sometimes have to choose whether to produce a good with a low environmental quality or, through a sustainability transition, jump to produce an eco-friendly good. Although environmentally friendly products lead to increased production costs for firms, consumers reward this effort by readdressing, to some extend, their demand toward them and by being willing to pay a higher price for a greener product (Wasik, 1996). However, a firm might be loath to shift to produce high quality goods since this could make it worse off in competing in prices. The reason is that the producers of low quality variant of the good might take advantage in producing goods due to their lower production costs, get a sizable market share and, accordingly, make the introduction of green products in the market not beneficial enough. Nonetheless, if all firms decide to adopt greener technologies in the production processes by offering high quality products, they might together benefit from the higher willingness to pay of consumers without the risk of being exploited by their competitors. In game theory this scenario is well represented by prisoner's dilemma in which the Nash equilibrium of the game is Pareto dominated by a different strategy profile that, however, is not an equilibrium since all the agents would have an individual

incentive to deviate from it. In our context, environmental policy instruments might give rise to a win-win situation by bringing firms to translate in a sustainable way toward the production of green products and make both environment and firm's economic performance be better off.

In this chapter we analyse a vertically differentiated duopoly under complete information, where single product firms decide simultaneously whether to supply a environmental high - or low - quality good (q_i) as discrete variable, and then, compete in price *à la* Bertrand. In this theoretical framework, we show that it is possible to find environmental policies that may simultaneously improve environmental quality and increase the profit of firms given the presence of green consumers that patronise the good they choose to buy, i.e., they specifically care about the environmental impact of the good they buy. In order to obtain our results we concentrated on a particular environmental policy instrument: an environmental standard. In order to comply with such a standard firms are forced to produce the high quality variant of the product. As we shall see, this instrument is able to determine a shifting toward a new profit-enhancing configuration by solving a coordination failure problem.

The chapter is organized as follows. In section 2 we provide a brief literature review on the topic. Then, in section 3 we outline a model of vertical product differentiation and solve for equilibrium price and quality without environmental regulation (section 4). In section 5 we introduce an environmental policy intervention, provide two numerical examples and then, formalize the condition under which a win-win situation arises (section 6). Finally, section 7 concludes the chapter.

3.2 Literature

Porter hypothesis was heavily criticized from scholars on the grounds of conventional economic thinking (see, for instance, Palmer 1995). The idea that firms neglect opportunities of innovation or any other decision that would allow them to improve the economic performance is irreconcilable with the neoclassical view of the firm as a rational profit maximizer agent (for a survey see the previous chapter).

Recently, other authors provided some new interpretations that would allow the Porter result to arise. Such mechanisms are the consequence of the presence of market failures, at different levels, that provide an opportunity for firms to benefit

from environmental regulation. In an economic growth context, Hart (2004) finds that an environmental policy intervention might boost R&D investments leading to economic growth. Simpson and Bradford (1996) through an international trade model content that a stricter environmental regulation might give rise to a shift of competitiveness from foreign to domestic firms owing to the existence of international externalities. Moreover, there are some studies that look at within-firm mechanisms that would lead to the adoption of green innovations as a result of environmental policy. According to Xepapadeas and de Zeeuw (1999), stricter environmental regulation generates positive (downsizing and modernization) effects on firms' competitiveness. Furthermore, Mohr (2002) and Greaker (2006) illustrate some within-firm mechanisms through which a more stringent environmental regulation leading firms to adopt new and eco-friendly technologies that could positively affect competitiveness.

3.3 The model set up

First of all, it is assumed that the environmental characteristics of a good do not influence the other characteristics of the good. Moreover, as is stressed by Brécard (2011), an environmentally friendly product is perceived as of higher quality than the standard product by consumers and is consequently more costly. Against this background, a number of consumer surveys show this feature of green products: most consumers perceive them as having a higher (environmental) quality than their competitors. Indeed, European Commission (2008, 2005) and the OECD (2002) studies emphasize that if they were sold at the same price as their more polluting counterparts, a large majority of consumers would turn immediately towards green products, given their environmental sensitiveness. Therefore, a further important aspect of this model comes from the assumption of the presence of green consumers that patronise the good they choose to buy (i.e., they specifically care about the environmental impact of goods they buy).

We consider a vertically differentiated duopoly under complete information where single product firms decide whether to produce a high (low) environmental quality good (q_i) as discrete variable, and then, compete in price *à la* Bertrand. As in the models of vertical product differentiation developed by Mussa and Rosen (1978) and Cremer and Thisse (1999), each firm offer a good of environmental quality q_i, which can be high (i = H) or low (i = L) and compete in price p_i. Production costs are given

by: $C_i(x) = F_i + c_i x^2$, where x indicates the output level and F_i, c_i are cost-specific parameters[2].

Let p_i be the price of the good with quality q_i, then the individual firm's profit function is:

$$\Pi_i = (p_i x - C_i(x)), \; i = H, L.$$

In the derivation of the demand side we adopt largely the same setup as in Mussa and Rosen (1978) and Gabszewicz and Thisse (1979): there is a continuum of consumers differing in the environmental concern, and the consumer types are identified by the index θ, uniformly distributed with density equal to one in the interval [0, 1]. Parameter θ represents the consumers' marginal willingness to pay for a good produced according to green standards. Each consumer buys at most one unit of variety $i = H, L$, whereby his/her net utility (or consumer's surplus) is $u_i(\theta) = \theta q_i - p_i$ if he/she buys a good of environmental quality q_i at price p_i and zero if he/she does not buy any good. Therefore, θq_i represents the willingness to pay for quality q_i, p_i the price of product *i*.

3.4 Price and quality competition

We are now in a position to examine our two-stage game. The time structure of the game is as follows:

- At stage 1 the two firms decide simultaneously the level of the environmental quality for their goods.
- At stage 2 firms choose their prices $p_i, i \in \{H, L\}$ simultaneously, consumers decide from which firm to buy, and payoffs are realized.

Figure 2: Time structure of the model

[2] The assumption that the cost function is quadratic -rather than linear- in quantity is convenient for two technical reasons: (i) it ensures that both firms are always active in equilibrium (provided fixed costs are low enough); (ii) it allows firms to have non-zero profits if they decide to produce the same environmental variant of the product and, afterwards, compete in prices (Crampes and Hollander, 1995).

On the basis of firm's choices, the market might have three different patterns:

- Both firms decide to produce the low quality variant of the good;
- Both firms decide to produce the high quality variant and sell the eco-friendly good;
- The two firms opt for different quality configurations of the good.

The first two cases entail homogeneous product, while the third results in a market with vertical differentiated products.The construction of the demand system is obtained by computing it for each quality mix. Denoting with p_{ij} and x_{ij} the price set and the demand faced by a firm producing with quality q_i when its rival produce with quality q_j (i,j = L, H).

Assume first the case where firms supply different quality levels. In this case the options for consumer are: (i) choosing the high environmental quality of the good; (ii) choosing the low environmental quality of the good; (iii) not buying.

We define the critical willingness to pay θ^Hat which the consumer is indifferent between buying the high and low quality good, and the critical willingness to pay θ^L at which the consumer is indifferent between purchasing the low quality good or not buying at all. A consumer with environmental awareness θ will buy the high environmental quality q_H if and only if $\theta q_H - p_{HL} \geq \theta q_L - p_{LH}$, from which we get $\theta^H = \frac{p_{HL} - p_{LH}}{q_H - q_L}$. Similarly, we can obtain $\theta^L = \frac{p_{LH}}{q_L}$. Since θ is uniformly distributed over the interval [0,1], the demand for the high quality variant is given by:

$$X_H = 1 - \theta^H = 1 - \frac{p_{HL} - p_{LH}}{q_H - q_L}.$$

and the demand for the low quality good is:

$$X_L = \theta^H - \theta^L = \frac{p_{HL} - p_{LH}}{q_H - q_L} - \frac{p_{LH}}{q_L}$$

Secondly, assume that both firms offer the same environmental quality q_i. In this context consumers could either buy one unit of good or not buy.

Let us assume first that both firms opt for producing goods with high environmental quality (q_H). For a consumer of type θ it is optimal to purchase one unit of the product if and only if $\theta q_i - p_i \geq 0$, being p_H in this case the lowest available price in the market. Hence the market demand of a good with high

environmental quality is given by the mass of consumers with $\theta \geq \frac{p_i}{q_i}$, i.e.,

$$X_H = \max\left\{1 - \frac{p_i}{q_i}, 0\right\}.$$

3.4.1 Price competition game

We solve the game backwards starting from the second stage, the price game. Firms choose prices subject to their previous choices for the environmental quality. When firms offer different environmental qualities and compete in prices, they choose p_{HL} and p_{LH} in order to maximize the following function:

$$\max_{p_{HL}} \pi_{HL} = (p_{HL} - c_H)\left(1 - \frac{(p_{HL} - P_{LH})}{q_H - q_L}\right) - F_H$$

and

$$\max_{p_{HL}} \pi_{LH} = (p_{LH} - c_L)\left(\frac{(p_{HL} - P_{LH})}{q_H - q_L} - \frac{P_{LH}}{q_L}\right) - F_L$$

From the First Order Condition (FOC) we obtain the following reaction functions:

$$\frac{\partial \pi_{HL}}{\partial p_{HL}} = \frac{(q_H - q_L)^2 + p_{LH}(q_H - q_L) + 2p_{LH}c_H + 2c_H(q_H - q_L)}{2(q_H - q_L) + 2c_H}$$

$$\frac{\partial \pi_{LH}}{\partial p_{LH}} = \frac{q_L^2(q_H - q_L)p_{HL} + 2c_L q_H q_L p_{HL}}{2q_H\, q_L(q_H - q_L) + 2c_L q_H^2}$$

From the above system of equations it is possible to derive the prices at equilibrium, from them the quantities and finally the profits.

With regard to the firm producing low quality good we obtain:

$$p_{LH}^* = \frac{q_L(q_L(q_H - q_L) + 2c_L q_H)(q_H - q_L + 2c_H)}{\psi}$$

$$x_{LH}^* = \frac{q_L q_H(q_H - q_L + 2c_H)}{\psi}$$

$$\pi_{LH}^* = \left(\frac{q_L q_H(q_H - q_L + 2c_H)}{\psi}\right)^2 q_H(q_L(q_H - q_L) + c_L q_H) - F_L$$

While for the firm producing the environmental friendly good we obtain:

$$p_{HL}^* = \frac{2q_H(q_L(q_H - q_L) + c_L q_H)(q_H - q_L + 2c_H)}{\psi}$$

$$x_{HL}^{*} = \frac{2q_H(q_L(q_H - q_L) + c_L q_H)}{\psi}$$

$$\pi_{HL}^{*} = \left(\frac{2q_H(q_L(q_H - q_L) + c_L q_H)}{\psi}\right)^2 (q_H - q_L + 2c_H) - F_H$$

with $\psi = 4q_H(q_L(q_H - q_L) + q_L c_H + q_H c_L + c_L c_H) - q_L(q_L(q_H - q_L) + 2q_L c_H + 2q_H c_L)$.

When both firms offer the same environmental quality q_i, the market structure is given by two symmetric firms competing in prices that sell a homogeneous good. Let $\Pi_{ii}^{a}(p_{ii}^{a}, p_{ii}^{b}) \equiv p_{ii}^{a} x_{ii}^{a} - C_i(x_{ii}^{a}(p_{ii}^{a}, p_{ii}^{b}))$ denote the profits of firm a in this symmetric quality game when it sets price p_{ii}^{a} and its competitor sets price p_{ii}^{b}.

The characterization of the equilibrium price in the symmetric case departs from the classic Bertrand paradox with price equal to marginal cost (which is the unique Nash equilibrium when firms have constant marginal costs), due to the existence of strictly convex costs. In fact, Dastidar (1995) proved that in a Bertrand model with symmetric firms and strictly convex costs the Nash equilibria are necessarily non-unique. Specifically, a pure strategy Nash equilibrium is characterized by both firms setting the same price p_{ii}^{*}, which is bounded by two thresholds: $\underline{p_i} \leq p_{ii}^{*} \leq \overline{p_i}$, where $\underline{p_i}$ and $\overline{p_i}$ are defined by the following condition:

$$\Pi_{ii}^{a}\left(p_{ii}^{a} = \underline{p_i}, p_{ii}^{b} = \overline{p_i}\right) \equiv -F_i$$

$$\Pi_{ii}^{a}(p_{ii}^{a} = \overline{p_i}, p_{ii}^{b} = \overline{p_i}) \equiv \overline{p_i} X_i(\overline{p_i}) - C_i(X_i(\overline{p_i})).$$

In words, $\underline{p_i}$ is the lowest price compatible with an equilibrium and it is defined as the price that equals average variable costs, making firms indifferent between producing at $\underline{p_i}$ and not producing. While $\overline{p_i}$ is the highest price compatible with a Nash equilibrium and it is defined as the price such that every firm is indifferent between setting the equilibrium price $\overline{p_i}$ (and hence splitting the demand evenly) and cutting marginally the price in order to exclude its rival and serve the whole demand.

For each game, the location of the equilibrium price in the interval $\left[\underline{p_i}, \overline{p_i}\right]$ can be interpreted as the degree of strength of price competition. The situation with $p_{ii}^{*} = \underline{p_i}$ can be seen as the one with the toughest competition and $p_{ii}^{*} = \overline{p_i}$ as the one with the mildest competition. Following Dastidar (1995), and depending on the degree of price competition, the price $p_{ii}^{a*} = p_{ii}^{b*} = p_{ii}^{*}$, the demand faced by each firm

$x_{ii}^{a*} = x_{ii}^{b*} = x_{ii}^{*}$ and firm profits $\Pi_{ii}^{a*} = \Pi_{ii}^{b*} = \Pi_{ii}^{*}$ in equilibrium can be parameterized in the following way:

$$p_{ii}^{*} = \frac{c_i q_i}{c_i + (2-\Phi)q_i}, x_{ii}^{*} = \frac{q_i(2-\Phi)}{2(c_i + (2-\Phi)q_i)}$$

$$\Pi_{ii}^{*} = p_{ii}^{*} x_{ii}^{*} - C_i(x_{ii}^{*}) = \frac{c_i q_i^2 (2-\Phi)\Phi}{4(c_i + (2-\Phi)q_i)^2} - F_i$$

where Φ represents the (inverse of the) intensity in the price competition and it can assume values in the interval $\left[0, \frac{4}{3}\right]$. In particular $\Phi = 0$ corresponds to the case $p_{ii}^{*} = \underline{p_i}$, while $\Phi = \frac{4}{3}$ corresponds to $p_{ii}^{*} = \overline{p_i}$ and $\Phi = 1$ corresponds to the Bertrand reference case of price equal to marginal cost.

3.4.2 Quality choice game

As we said before, firms at first stage decide the environmental quality of the good they are willing to produce: q_H or q_L by focusing on the consequences of their choice for the second stage. It is possible to describe the environmental quality game of the firms as a simultaneous game in classical form as follows:

		FIRM 2	
		q_H	q_L
FIRM 1	q_H	$(\pi_{HH,}^{*}\pi_{HH}^{*})$	$(\pi_{HL,}^{*}\pi_{LH}^{*})$
	q_L	$(\pi_{LH,}^{*}\pi_{HL}^{*})$	$(\pi_{LL,}^{*}\pi_{LL}^{*})$

In game theory, the Nash equilibrium is a solution concept of a non-cooperative game involving two or more players, in which each player is assumed to know the equilibrium strategies of the other players, and no player has anything to gain by changing only their own strategy unilaterally. If each player has chosen a strategy and no player can benefit by changing strategies while the other players keep theirs unchanged, then the current set of strategy choices and the corresponding payoffs constitute a Nash equilibrium. Therefore, the prevailing quality mix of the firms will be the Nash equilibrium of this game.

3.5 Environmental standards and the Porther hypothesis

The aim of this study is to try to answer the following research questions: *is it possible that both firms be explicitly better off as a result of an intervention of environmental policy? And if it is possible, which are the economic instruments that allow this result?*

Let us assume that the government implements a new policy designed to promote the use of more environmentally friendly technologies in order to discourage the production of the standard (low quality) variants of a given good.

Often, the discussion on environmental policy instruments is carried out as if there were only two applicable instruments: environmental standards and taxes on emission. However, many dedicated instruments exist with different aims and features. In jargon, environmental policy instruments are often viewed as "marked based instruments" and "command and control instruments". Many environmental policy instruments frameworks have been suggested to classify and compare the environmental mechanisms of regulation. One useful typology that relies on World Bank Report 1997 refers only to three major categories: direct regulation (command and control), economic instruments and soft instruments.

Firstly, direct regulation includes environmental standards, commands and prohibitions in relation to inputs, processes and outputs. "IPPC Directive" gives a typical example. It is a standard set by the European Union with the "Integrated Pollution Prevention and Control" Directive (96/61/EC). Such standard requires the issuance of an authorization for all industrial and agricultural activities that have a high pollution potential. This authorization may be granted only if certain environmental conditions are met, to ensure that the companies bear responsibility for preventing and reducing pollution that they may cause. Secondly, economic instruments include duties (e.g. taxes, charges), tradable emission permits (e.g. EU Emissions Trading Scheme) and environmental liability. Finally, soft instruments include voluntary industry agreements, communication and information measures as well as environmental certification schemes (e.g. ISO 14001, EU Environmental Management and Auditing Scheme (EMAS) or the EU Ecolabel).

In order to simplify the exposition we concentrate on a simple instrument such as an environmental quality standard that forces firm that produce the low quality

variant of the good to adopt a new and greener technology[3].

For a given amount of investments necessary to comply with an environmental standard (S), the regulated environmental quality decision can be viewed a simultaneous game in normal form as follows:

		FIRM 2	
		q_H	q_L
FIRM 1	q_H	$(\pi^*_{HH,}\pi^*_{HH})$	$(\pi^*_{HL}-S\ ,\pi^*_{LH})$
	q_L	$(\pi^*_{LH}-S,\pi^*_{HL})$	$(\pi^*_{LL}-S,\pi^*_{LL}-S)$

From the above game matrix is possible to perceive the intuition behind our model of vertical product differentiation and show how it could essentially yield a win-win outcome and, as a consequence, provide additional support for the Porter's hypothesis. The economic idea at the basis of this result can be explicated as follows. If firms in our model are trapped at an equilibrium that is not Pareto efficient ($q_Lq_H; q_Hq_L;\ q_Lq_L$) , then a proactive and new environmental policy (i.e. environmental standard) on those firms producing low quality variant might make both of them better off allowing them to exploit a greater willingness to pay of consumers for high environmental quality products. To better understand, let us think about a situation where firms are producing a good with a low environmental quality (q_L) and there is a more environmentally friendly alternative available (q_H). In this circumstance, even if both firms would enjoy an higher profit from a concerted choice to adopt the higher quality good, it would be quite unlikely to do so individually because such decision could virtually expose it to the opportunistic behaviour of the rival that might place on the market the low quality good at a lower price, getting a large share of the market and thus, an higher payoff. In this scenario, environmental standard might lead a win-win situation by motivating one or both firms to shift on a more sustainable and profitable production. Briefly, this idea can be summarized in the following proposition:

Definition 1: *an environmental standard will give rise to a win-win situation if*

[3] All of the relevant results are compatible with other environmental policy instruments. The simplest and most straightforward alternative to this strategy would be to impose a penalty or a lump-sum tax on those firms that produce the low environmental quality of the good. This lump-sum tax could be interpreted as a license that must be purchased by any firm wishing to produce goods of quality q_L.

the Nash equilibrium of the game observable in a context of a public intervention generates higher payoffs for both firms than those gained by a Nash equilibrium of the quality game in absence of an environmental policy.

Generally, the win-win situation is achievable with any equilibrium pattern that ensures higher payoff for firms on one hand, and a reduced environmental damage on the other hand. However, the idea we emphasised before suggests that this result arises when the equilibrium of the game moves from (q_L, q_L) in the absence of environmental policy to (q_H, q_H) when standards have been set. We start with two examples through which our model of vertical differentiation can actually replicate this theoretical possibility in order to better understand the necessary and sufficient conditions under which a win-win situation can emerge.

EXAMPLE 1.

Let us imagine that producers of plastic bags in a given market have to decide either to continue using regular plastic (q_L) or to start producing plastic bags using bio-plastic derived from bio-waste valorisation (q_H)[4]. Those firms that decide to make their product eco-friendly would not have to buy new equipment or other tools in order to shift their modes of production, but we suppose that they would sustain only higher input costs (for example, they would have to buy bio-plastic derived from bio-waste at an higher price). Namely, the quality shift would generate an increase only in marginal costs of production. Moreover, let us assume that this market is a duopoly described by the following parameter configuration:

$$\left(q_H, q_{L,} F_H, F_L, c_H, c_{L,} \Phi\right) = (150,70,0,0,250,50,1)$$

The numerical values assigned to the parameters are in line with the model assumptions. In particular, it is easy to note that:

- $q_H > q_L$ reflects the greater environmental quality of the plastic bags produced using bio-plastic derived from bio-waste valorisation with respect to the regular plastic bags;
- $F_H, F_L = 0$ since we assumed no differences in fixed costs for the above example.
- $c_H > c_L$ reflects the fact that firms which are willing to produce plastic bags derived from bio-waste have an higher price marginal cost than the others.

[4] We assume the existence of a well-established technological alternative to the current one.

- Φ represents the (inverse of the) intensity in the price competition and it can assume values in the interval $\left[0, \frac{4}{3}\right]$. In particular $\Phi = 1$, in our example, corresponds to the Bertrand reference case of price equal to marginal cost.

Now, trough some straightforward computations the related payoff matrix for environmental quality decision game result to be:

FIRM 2

FIRM 1		q_H	q_L
	q_H	$(8.79, 8.79)$	$(2.12, 16.49)$
	q_L	$(16.49, 2.12)$	$(4.25, 4.25)$

It is worth to mention that the above game has the structure of a typical prisoner's dilemma paradigm in which the unique Nash equilibrium, (q_L, q_L), is not efficient from the perspective of firms because both producers of plastic bags would be better off if they were able to set an agreement to use only bio-plastic derived from bio-waste. However, the second outcome is not a Nash equilibrium, since each firm has incentives to deviate from it.

Now assume that the government set an environmental standard S to be complied with on any producer that continues to use regular plastic. The new pay off matrix of the quality choice game is now the following:

FIRM 2

FIRM 1		q_H	q_L
	q_H	$(8.79, 8.79)$	$(2.12, 16.49 - S)$
	q_L	$(16.49 - S, 2.12)$	$(4.25 - \mathrm{S}, 4.25 - \mathrm{S})$

The new payoff matrix shows that the environmental standard forces low quality producers to adopt a greener technology, giving rise to compliance costs, in such a way as to reduce the payoffs of some of them who would like to behave opportunistically without increasing those of others producers. At first sight, the policy would seem to be totally detrimental to the whole industry. However, it is easy to understand that, for any environmental standard S that implies higher

production costs (S > 7.70), the Nash equilibrium of the game shifts to (q_H, q_H). As a result, if we look at the previous and subsequent equilibrium payoff and compare them, we will find that the profits of both plastic bags producers increase when a sufficiently high environmental standard is set.

The economic intuition at basis of this result is that in the original quality choice game, both producers would be better off if they would have shifted together from q_L to q_H. However, this does not occur since the firm that choose to produce the eco-friendly good would be worse off given the opportunistic behaviour of its rival. In particular, by producing the low quality good (i.e. plastic bag using regular plastic) the producer would sustain a lower cost, thus charging a lower price and, as a consequence, gains a large share of the market. Therefore, the environmental standard is able to suppress this opportunistic behaviour and, consequently, solve the coordination failure in the industry.

EXAMPLE 2

Now let us think about an industrial market in which the producers of a certain good make use of engines fuelled with a very polluting fossil fuel (q_L). These firms could decide to shift to a cleaner fuel (q_H) that entails the same unit cost and that generates the same heat power, if compared with the polluting one. Therefore, the only requirement is the installation of new engines. In this case, the better environmental quality of a product does not affect its variable costs, but rather it implies a fixed cost of adoption (i.e. buying a new engine). Moreover, let us assume that this market is still a duopoly described by the following parameter configuration:

$$\left(q_H, q_{L,} F_H, F_L, c_H, c_{L,}\, \Phi\right) = (110, 100, 0.7, 0, 200, 200, 1.3)$$

Also in this case the numerical values assigned to the parameters are in line with the assumptions of the model and, through some straightforward computations, the related payoff matrix for environmental quality decision game results to be:

		FIRM 2	
		q_H	q_L
FIRM 1	q_H	$(6.48, 6.48)$	$(6.15, 5.42)$
	q_L	$(5.42, 6.15)$	$(6.24, 6.24)$

Differently from the previous example the structure of this game is no longer consistent with a prisoner's dilemma since both (q_L, q_L) and (q_H, q_H) are Nash equilibria considering that all other quality choice combinations (q_L, q_H) and (q_H, q_L) entail smaller payoffs for duopolists. Moreover, the fact that the high quality equilibrium (q_H, q_H) dominates the low quality one (q_L, q_L) from the firms' perspective provides possibility for a win-win situation to appear. To this end, let us assume now that the government set an environmental standard S to be complied with on any producer that continues to use regular engines fuelled with fossil fuel in order to drastically reduce polluting emissions. The new pay off matrix of the quality choice game is now the following:

FIRM 2

FIRM 1		q_H	q_L
	q_H	$(6.48, 6.48)$	$(6.15 - S, 5.42)$
	q_L	$(5.42, 6.15 - S)$	$(6.24 - \mathrm{S}, 6.24 - \mathrm{S})$

Still, the above payoff matrix shows as an environmental standard, by discouraging the production of low quality variant of the good, solves the coordination failure between producers. In particular, in this case, the environmental policy eliminates the multiplicity of equilibria and makes the most efficient equilibrium (q_H, q_H) prevailing. To this end, it is suffices to set an environmental standard S causing compliance costs greater than 0.09 on those firms opting for low quality variant of the good for having a unique Nash equilibrium of the game (q_H, q_H). Consequently, if we look at the previous Nash equilibria and at the subsequent ones, we will find that the profits of producers increase as a result of an environmental policy.

The above examples show, at first glance, that a win-win result can theoretically emerge irrespective of the nature of the cost increases generated by any given quality improvement of the products. Moreover, such a result is directly dependent on the occurrence of certain conditions. In the next section, we will formalize the necessary and sufficient condition in order to obtain an improvement either on the firms' economic performance than on environmental point of view as a result of an environmental policy.

3.6 Deriving the win-win equilibria conditions

As discussed above, we are considering a model of vertical product differentiation where two firms simultaneously choose the environmental quality of the good they produce - which can either be high (q_H) or low (q_L) - and subsequently compete on price *à la* Bertrand. We are now in a position to formalize what does it mean to achieve a win-win configuration in this framework and what conditions need to be met.

Firstly, an environmental policy (characterised, for example, by an environmental standard enforced on those firms which produce the low quality variant of the good) will give rise to a win-win configuration if the Nash equilibrium of the game resulting from such policy provides higher payoffs for both firms than those achieved with a Nash equilibrium of the game in absence of an environmental public policy (unregulated game). Taking into account the original definition of a win-win configuration, we know from the Porter's contributions (1995) that it is compatible with any equilibrium outcome. However, the previous specification suggests that such configuration arises when the equilibrium of the game moves from (q_L, q_L) in the absence of environmental regulation to (q_H, q_H) once regulation have been implemented and such shift implies higher payoffs for both firms.

Secondly, an environmental policy (i.e. environmental standard imposed on those firms which produce the low quality variant of the good) will lead to a win-win configuration only if (q_L, q_L) is a Nash equilibrium of the unregulated quality choice game and (q_H, q_H) is the unique Nash equilibrium of the game resulting from such environmental policy. Namely, in order to achieve a win-win outcome, the early equilibrium of the game needs to be different from the one resulted from regulation. If not, the establishment of an environmental standard would not have effect on firms' payoffs. Moreover, a win-win situation will never arise if the environmental regulation brings only one firm to modify its production strategy. This is a simple characterization of revealed preference and, as emphasized by Echenique et al. (2005) it has a straightforward understanding since a possible unilateral strategy change was already available in the unregulated game and no firm find it optimal to alter its strategy. Therefore, the necessity of a simultaneous strategy change, and the fact that the firms are symmetric, ensures that a win-win result can be obtained only if environmental regulations lead firms to shift from the initial equilibrium (q_L, q_L) to the final and unique equilibrium (q_H, q_H).

From the above propositions it is immediate to obtain the following result, which provides us the necessary and sufficient conditions under which environmental regulation can yield an increase in firm payoffs in terms of profits.

Necessary and Sufficient Conditions: Environmental regulation can provide a win-win configuration if and only if the resulting conditions are met:

1. $S > max\{\pi_{LL}^* - \pi_{HL}^*, \pi_{LH}^* - \pi_{HH}^*\}$
2. $\pi_{HL}^* < \pi_{LL}^* < \pi_{HH}^*$

- Condition 1 entails that the implementation of an environmental standard S is able to make the configuration (q_H, q_H) the unique Nash equilibrium of the environmental quality decision game after policy intervention. In this context, $S > \pi_{LH}^* - \pi_{HH}^*$ is required to switch on the desired equilibrium configuration (in the first example, $S > \pi_{LH}^* - \pi_{HH}^* = 16.49 - 8.79 = 7.70$ was the condition able to eliminate any opportunistic behaviour of firms), and $S > \pi_{LL}^* - \pi_{HL}^*$ is similarly required to avoid (q_L, q_L) from being an equilibrium and allow thus, (q_H, q_H) to be the unique Nash equilibrium of the game.

- Condition 2 is twofold. The first inequality $(\pi_{HL}^* < \pi_{LL}^*)$ allows us to understand that (q_L, q_L) is an equilibrium configuration of the quality choice game in absence of environmental regulation. The second inequality $(\pi_{LL}^* < \pi_{HH}^*)$ is crucial since ensures that both firms would benefit if they concurrently shift from the early equilibrium outcome (q_L, q_L) to the high quality variant equilibrium of the game (q_H, q_H).

It is easy to check that the first condition $(S > max\{\pi_{LL}^* - \pi_{HL}^*, \pi_{LH}^* - \pi_{HH}^*\})$, given a value of S sufficiently high, is always met. What is really relevant for a win-win situation to arise is the fulfilment of the second condition.

Moreover, looking at the above conditions, two particular scenarios could emerge if we consider the further fulfilment of slightly different conditions. On the one side, considering that first condition always holds let us assume that not only the second condition is met but additionally the inequality $(\pi_{LH}^* > \pi_{HH}^*)$ result to be true in the first stage of the quality choice game. As it was shown in the first example, the fulfilment of this condition makes (q_L, q_L) the only possible Nash Equilibrium of the game. This configuration corresponds to a classical prisoner's dilemma paradigm in

which the new environmental regulation succeeds in shifting firm interests away from a not optimal equilibrium outcome. On the other side, we may assume just the opposite, that is ($\pi^*_{LH} < \pi^*_{HH}$). In this scenario, the structure of the quality choice game is no longer consistent with a prisoner's dilemma paradigm since both (q_L, q_L) and (q_H, q_H) are Nash equilibria – considering that all other quality choice combinations (q_L, q_H) and (q_H, q_L) entail smaller payoffs for firms – and the environmental regulation serves to dissuade the production of low quality goods in order to eliminate the multiplicity of equilibria and to guarantee the occurrence of a "desired" equilibrium in which both economic and environmental performance are achieved.

The examples presented in the previous section provided an exemplification of such possible scenarios allowing our model of vertical product differentiation to answer the research questions objective of this study. Namely:

How theoretical applicable is the Porter hypothesis within the context of a quality competition framework? Does the introduction of an environmental standard offer additional insights that allow a win-win situation to arise?

In this scenario, environmental regulation could open the door to a win-win situation by motivating both firms to take on the "green" good, to their own benefit and that of the environment. This intuition can be formalized in the following preposition:

Proposition 1: (Necessary Condition) An environmental policy (characterized as a rule that imposes the standard S > 0 on any firm choosing to produce the environmentally damaging variant of the good) can yield a win-win situation only if (q_L, q_L) is a Nash equilibrium of the quality choice game and (q_H, q_H) is the unique Nash equilibrium of the regulated quality choice game.

3.7 Concluding remarks

Twenty years ago, by declaring that well-designed regulation could actually enhance competitiveness, Michael Porter certainly generated enormous interest among scholars, policymakers, businesses, and pressure groups. Indeed, much has been written about what has since become known simply as the Porter Hypothesis.

Our observations depart from much of literature on the Porter Hypothesis on one key point: they describe a win-win result that rests on a demand-driven mechanism (consumer preferences for cleaner goods) rather than on any productivity gains or

cost savings brought on by environmental innovation. In particular, in this chapter we analysed a vertically differentiated duopoly under complete information, where single product firms decide whether to supply a high- or low-quality good (q_i) as discrete variable, and then, compete in price *à la* Bertrand. We found that the framework of this game can ensue in a typical prisoner's dilemma as a meaning that, in absence of an environmental policy, both firms choose the low environmental quality of the product although they might be better off shifting together toward the environmentally friendly product. Under this circumstance, an environmental policy could improve the environmental quality while simultaneously enhances firms' economic performance. In order to obtain our results we concentrated on a particular environmental policy instrument: an environmental standard that forces firms to produce the high quality variant of the product. This instrument is able to determine a shifting toward a new profit-enhancing configuration by solving a coordination failure and, at the same time, it is able to promote a transition toward more sustainable modes of production and, accordingly, consumption processes.

This "double effect" might be achieved by involving further forms of environmental regulation. A concrete alternative could be to set a lump-sum tax on those firms producing the low quality good. Analogous effects could also appear applying a Pigouvian tax that makes low quality variant of the good more costly for firms with respect to the high quality variant.

It is opportune to stress that, among our model's assumption, the fact that environmental quality of the product has ben thought as a discrete decision for firms results to be central in order to derive our findings. First of all, because this assumption permits to have equilibria in which firms opt for the same quality variants[5]. Second, the opportunity to achieve a win-win situation rests strongly on the restricted possibility of choosing on quality levels for firms.

Finally, it is worth stating that our findings provide a theoretical basis for the Porter hypothesis to succeed by focusing on a pure market mechanism rather than on any market failure that offers a field for environmental regulation to benefit firms and, more research is certainly needed to better understand the different market mechanisms at play.

[5] This conflicts with the main finding in models of price-quality competition with continuous quality, in which the equilibrium always entails a certain degree of product differentiation. See, for example, Shacked et al. (1982)

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4. Sustainability transitions: *a review of the literature.*

4.1 Introduction

The study area that has received increasing attention over the last years due to its earnestness is related to the global climate change challenges and its various effects on ecosystems and on resources depletion. Particularly, the consumption and production processes that are taking place worldwide are no more tolerable owing to the limited resource that the planet offers and the effects on the environment in the terms of pollution and climate change. While most of these challenges are related to environmental and social problems, economic problems are pressing as well. Therefore, the increasing costs of fossil-based raw materials due their scarcity on the one hand, and the need for more sustainable modes of production and consumption on the other, has become a key objective for policy makers and a priority for people.

It is widely believed that continuing in this way is simply unsustainable and that a transition towards a bio-based economy is heavily needed. However, as emphasized by Geels and Schot (2010), transition involves long-term changes involving different dimensions (technological, material, organizational, institutional, political, economic, and socio-cultural) of the socio-technical systems. But, often it is easier said than done, since these unsustainable systems are profoundly part of the society (since they have developed over a significant amount of time) making it often "locked-in". For instance, the transition towards a transportation system based on electrical energy suffers infrastructural related problems (i.e. absence of needed recharging stations) that hinder the diffusion of the electric vehicle. At the same time, economic agents are not willing to invest in recharging stations if there are only a few electric vehicles driving around.

In order to better understand the basic dynamics of a transition, several studies have been carried out looking at the theoretical foundations of these transitions towards a sustainable paradigm. These studies are often derived from various strands of research and disciplines, resulting in a myriad of approaches aimed at understanding and assessing transitions. The concern of how to encourage and govern a transition toward sustainability has increasing gathered attention both in the

policy arena (OECD, 2011; UNEP, 2011) and in social-science research. In theoretical terms, four frameworks so far have achieved a particular importance in transition studies. These include the multi-level perspective on sociotechnical transitions (Geels, 2002; Geels and Schot, 2007b; Smith et al., 2010), the strategic niche management (Kemp et al., 1998; Raven and Geels, 2010; Smith, 2007), the transition management (Kern and Smith, 2008; Loorbach, 2010), and the technological innovation systems (Bergek et al., 2008; Hekkert et al., 2007).

This chapter seeks to provide a description of the more important theories and approaches to understand and explain (sustainability) transitions and their related main concepts by reviewing them and providing some critical considerations in order to have a clear idea about the progresses of sustainability transition studies.

The next section provides a summary of highlights of the evolution from "transition" concept to the notion of "sustainability transition". The third section reviews different approaches to research and understand transitions. Then, a general critique on these approaches is provided in the fourth section, which is followed by a section on the strengths, contributions and potential lines of future research on sustainability transition. The concluding section provides some final thoughts on the topic under investigation.

4.2 From historical transitions to sustainability transitions

The first literary mention to the concept of "transition" occurred in the 19th century when Alex de Tocqueville[6] coined such word to depict a revolutionary change in low relationship between master and slave, and described it as an historical phase in which the bourgeois and aristocratic classes did not have anymore a recognized right and thus the strength to stay in power (Coenen and Huther, 1996). During the last 50 years, the concept of transition assumed great relevance in other areas, such as political and power relations to identify the changes that have taken place in economic and social views of some countries. With the collapse of Communist regime in Eastern Europe and with the fall of the Berlin Wall in 1989, there were the first major transitions in communist countries towards market-based economies. As a consequence, among the social sciences there was the advent of a new discipline called "transitology" (Marody, 1996).

[6] The Viscount Alexis Henri Charles de Clérel de Tocqueville (Paris, 29 July 1805 - Cannes, 16 April 1859) was a philosopher, political and historical French.

In the 1990s, the "transition" concept was borrowed by researchers involved in sociotechnical studies related to environmental issues. This very area of enquiry had received increasing attention since the 1980s when the World Commission of Environment and Development introduced the concept of "sustainable development", defined as the *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987) as a global normative aim. This new perspective *opened the doors* to new interests in the research on transitions towards a sustainable economy. Around the end of the millennium "transition studies", especially after that policy makers recognized transition thinking, became a quite relevant field of research so as to diffuse the conception of a transition theory in order to comprehend the basic dynamics of the phenomena to encourage sustainable shifts in the coming years (van den Bosch, 2010).

Within the sociotechnical research context, the concept of "transitions" originally concerned changes of limited ranging within society or essential subsystems (Rotmans et al., 2001). Lately, such idea of "transitions" has been reconsidered in order to explicitly comprehend *"the fundamental changes in structure (e.g. organizations, institutions), culture (e.g. norms, behaviour) and practices (e.g. routines, skills)"* (Loorbach and Rotmans, 2010). In other words, the prevailing approach in which a societal necessity (e.g. the need for transportation, energy, or agriculture) is met changes drastically assuming wide-ranging perspective; this might last generally one or two generations (25–50 years) to fully occur (Alkemade et al., 2011). For instance, the issue concerning climate change cannot be faced without profoundly changing the structures of the sociotechnical system. Climate change is the consequence of the nature of our productions and consumption processes, and dealing with this problem entails a long-term transition towards more sustainable systems (Raven and Verbong, 2009). Embracing this goal, and attempting a distinction with previous transition, *sustainability transitions* can be defined as long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption (Geels and Schot, 2010).

Sustainability transitions differ from historical transitions in the following aspects (Geels, 2010):

- some of new environmental concern will take a conspicuous amount of time to show their effects in tangible way. Therefore, the need of sustainability is not strongly felt so urgent as it should for some environmental problems such as acid rain, smog, global warming, etc.;
- transitions towards sustainability requires composite solutions rather than a so-called "magic bullets" as it happens in historical transitions;
- sustainability often is a normative aim that addresses strategies and actions of the actors. Therefore, guidance and governance often play a particular role (Smith et al., 2005).

Due to their intrinsic complexity, sustainable transitions cannot be totally planned or imposed from the outside, but rather, they could be encouraged and supported with respect to their dimensions by political as well as regulatory and institutional actors that can be expected to play a major role (Kemp and Loorbach, 2003).

Against this background, recently the discussion on how to promote and govern a sustainable transition has attracted particular interest in the international community of researcher in the field of transition studies. This line of research has become more and more prominent so as to collect an increasing number of publications. Additionally, several institutional structures have been established lately in order to spread the visibility of transition studies. The first two international conferences on Sustainability Transitions in 2009 and 2011 have gathered more than 300 scholars from all over the world, then a new journal titled "Environmental Innovation and Societal Transitions" was recently founded and the Sustainable Transitions Research Network (STRN) was established to connect scholars and to encourage exchange of knowledge and ideas - www.transitionsnetwork.org - (van den Bergh et al., 2011).

4.3 Conceptual approaches on transitions

Socio-technical transitions, system innovations, and the emergence of sustainable technologies have gained attention in social-sciences over the last decade, and several conceptual frameworks have been advanced for the analysis of these processes (Grin et al., 2010). This section deals with a review of the more prominent transition approaches that are believed to be relevant for the theoretical outlining of sustainability transitions. As mentioned in the introduction these are: (1) the Multi-

Level Perspective, (2) the Strategic Niche Management, (3) the Transition Management and (4) the Technological Innovation Systems. For the considered approaches, first, it will be outlined the theoretical background, then, it will be discussed the basic ideas and views on transitions, and finally, it will be addressed strengths and weaknesses. However, It should be emphasized that the above-mentioned approaches are not the totality of the proposed ones, but rather the more considered and studied. In this context, it is important to consider that there are several other relevant theoretical approaches, which have been used to study and explain the particularities of transitions. These include general theories, such as evolutionary economic theory (Nelson and Winter, 1982) and actor network theory (Law and Hassard, 1999), as well as approaches with a more specific focus on technology, such as social construction of technology (Bijker et al., 1987).

We will restrict the next subsection on the review and analysis of the aforementioned four approaches, since they embrace general and systemic views of socio-technical systems.

4.3.1 Multi-level perspective

The Multi-Level Perspective (MLP) is an approach dealing with, inter alia, the complex issue of sustainable development. It is a mix between evolutionary theory approaches and patterns of long-term changes. Particularly, it seeks to explain sociotechnical transitions through the interaction of three different levels: macro, meso and micro level – these corresponding respectively to landscape factors, technological regimes and innovation niches (Rip and Kemp, 1998; Geels, 2002).

Landscape (*macro*) refers to the overall socio-technical setting that comprehends both the intangible aspects of social values, views and political beliefs and the tangible aspects involving the institutions and the functions of the marketplace such as prices, costs, trade patterns and incomes. Therefore, it represents the set of elements or factors that can have a significant impact on the meso (regime) and micro (niche) levels.

Regime (*meso*) refers to the dominant practices, rules and technologies that provide stability and reinforcement to the prevailing socio-technical systems (Geels, 2004). Namely, the sociotechnical regime involves three interdepended elements: (i) a network of actors and social groups that adapts over time to the system dynamics; (ii) the set of formal and informal rules that address the behaviours and the actions of

actors in order to preserve and steer the nature of the socio–technical system; (iii) the set of material and technological components.

Niche (*micro*) a frequently used description for niches is a protected space, i.e., specific markets or application domains, in which radical innovations can develop without being subject to the selection pressure of the prevailing regime (Kemp et al., 1998). Through processes of social learning within multiple experiments, articulating promising expectations and heterogeneous networking, niche innovations can became mature and eventually compete with established technologies (Geels and Raven, 2006).

In accordance with the MLP, transitions arise as a consequence of dynamics at the different levels. Landscape factors could put pressure on current regimes and open windows of opportunities for niches to break through and conduce to important changes, or shifts, in socio-technical regimes.

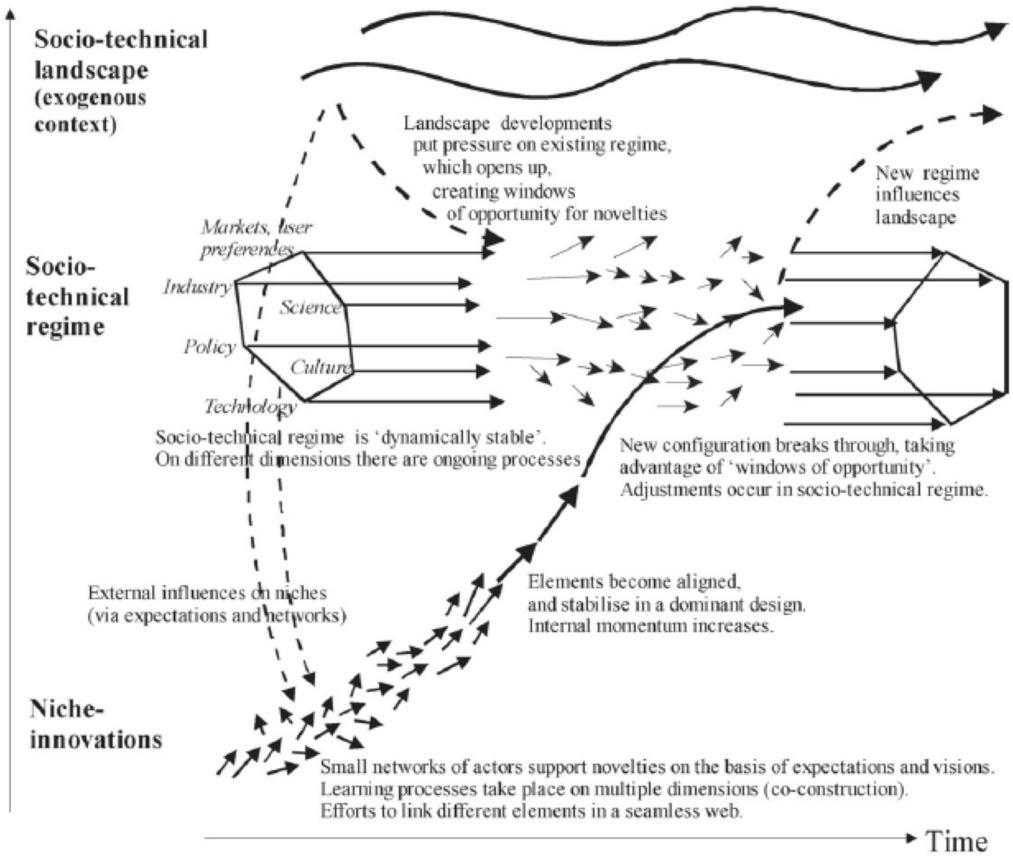

Figure 3. *Multi Level Perspective on Transitions (Geels, 2002).*

Geels and Schot (2007) develop a typology of four transition pathways: transformation, reconfiguration, technological substitution, and de-alignment and re-alignment. The following pathways differ in combinations of timing and nature of multi-level interactions:

- *Transformation path*: moderate landscape pressure at a moment when niches are not yet adequately mature, bring regimes to respond by modifying the direction of development paths and innovation activities.
- *De-alignment and re-alignment path*: if landscape pressures are divergent, big and unexpected they will increase regime problems, which destabilize the regime, leading to de-alignment. In the absence of sufficiently developed niches, emerging niches will compete to succeed and only one niche will become dominant, forming the core for re-alignment of a new regime.
- *Technological substitution*: significant landscape pressure in combination with sufficiently developed niches leads to dethroning of regimes by niches, which will break through and replace the existing regime.
- *Reconfiguration pathway*: symbiotic innovations, which are developed in niches, are initially adopted in the regime to solve local problems. They subsequently trigger further adjustments in the basic architecture of the regime.

These transition pathways contrast with the so-called *reproduction process* which occur in the absence of landscape pressures. Under this circumstance the regime remains dynamically stable and will reproduce itself. Radical niche-innovations might appear, but they have few possibilities to succeed as long as the regime is dynamically stable.

The MLP is a valuable theoretical approach in terms of scope and generalizability (since it succeeds in approaching different and complex situations) that aims to provide a real perspective of transitions in order to address the study of patterns, causes and impacts of different phenomena in transitions processes (Geels, 2011). Therefore, the MLP approach has been able to describe past (Geels, 2002, 2007) and current transitions (Kern, 2012; Nakamura et al., 2012). Despite the great success and attention achieved by the MLP approach, it has not escaped from criticism on three general points. The first critique regards empirical and analytical aspects. For example, Berkhout et al. (2004, p. 54) state: *"it is unclear how these conceptual levels should be applied empirically. By this we mean that a sociotechnical regime could be defined at one of several empirical levels"*. In the electrical sector one

might analysis a regime by looking at the primary fuel (coal, oil, gas) or by enlarging the analysis at the whole system (production, distribution and consumption of electricity). Therefore, what seems a regime shift at one stage might be perceived simply as an incremental transition in inputs for a broader regime. The second critique is the relative overlook of agency, particularly in representations (communities and interacting groups) such as Fig. 1. For example, Smith et al. (2005: 1492) state: *"MLP is overly functionalistic. Despite the breadth of the regime concept, there is a tendency to treat regime transformation as a monolithic process, dominated by rational action and neglecting important differences in context. We also argue that existing approaches tend to be too descriptive and structural, leaving room for greater analysis of agency".* The last critique concerns the great relevance that the approach recognizes on technological niches as the most important locus for the regime shift. For example, Berkhout et al. (2004, p. 62) argue: *"MLP-approaches are unlinear in that they tend unduly to emphasize processes of regime change which begin within niches and work up, at the expense of those which directly address the various dimensions of the sociotechnical regime or those which operate 'downwards' from general features of the sociotechnical landscape".*

In spite of these criticisms, defined constructive by Geels and Schot (2007), the MLP has gathered an increasing attention and academics are constantly contributing to the concept by focusing on topics such as interaction between niches and regimes, definition of operational limit, further interactions among the proposed levels, and empirical assessment of concepts. Moreover, the MLP is a valuable tool for policy makers to understand and thus, to address transitions in an efficient and effective way by placing the focus on both niche and regime levels (Geels, 2012).

4.3.2 Strategic niche management

Strategic Niche Management (SNM) is a recently developed analytical approach that is proposed expressly to enable the introduction and diffusion of very new sustainable innovations through societal experiments. SNM scholars state that for several new technologies, mainly with sustainability aims, market niches and consumer demand are not immediately available since the innovations are not always trivial changes from the prevailing set of technologies, but differ deeply from them. SNM was therefore designed to entail the management of particular type of innovations: (1) socially desirable innovations serving long-term goals such as

sustainability, (2) radical novelties that face a divergence with regard to existing infrastructure, user practices, regulations, etc. It is indeed for this reason that SNM scholars see real-world experimental projects, in which various stakeholders collaborate and exchange information, knowledge and experience, as important devices that precede market niche development (Schot and Geels, 2010).

Pioneering studies on SNM (see Kemp et al, 1998) theorized the process as a bottom–up process, in which innovations arise in technological niches, then under some critical circumstances achieve market niches, and finally replace and renovate the regime. The main research question, hence, was: how and under which conditions the successful emergence of a technological niche is achievable?

Grounded on a series of considerations from innovation studies, three internal mechanisms have been single out for technological niche to succeed (Elzen et al., 1996; Kemp et al., 1998; Hoogma et al., 2002): (i) *expectations* considered crucial for niche development because they provide direction to learning processes, (ii) *learning process* at multiple dimension (technical, cultural, infrastructural, societal and environmental) and (iii) *network formation* to create a constituency behind the new technology.

Firstly, expectations and visions, when positive, are necessary to "pull in" attention, resources and new actors potentially interested, especially, when the technological innovation is still in a early phase of development and its performance is still uncertain. Expectations also provide direction to development: they act as cognitive frames for making choices in the design process. Expectations will contribute to successful niche development if: they are robust (shared by more actors), they are specific (if expectations are too general they do not give any guidance), and they have higher quality (the content of expectations is substantiated by on-going projects) (Kemp et al., 1998; Hoogma et al., 2002).

Secondly, learning process is generally recognized essential for successful innovation (Kemp et al. 1998). Learning will arise both individually (as producers will increase their knowledge simply "by doing") and collectively. This second option suggests that firms and other actors involved in the technological niche will share their own knowledge (Lopolito et al., 2011).

Finally, building of social networks is important to facilitate interactions between relevant stakeholders, and provide the necessary resources (money, people, expertise). The formation of social networks is likely to contribute more to niche

development if: the networks are broad, i.e. multiple kinds of stakeholders are included to facilitate the articulation of multiple views and voices; the networks are deep, i.e. people who represent organisations, should be able to mobilise commitment and resources within their own organisations and networks through regular interactions (Elzen et al., 1996; Hoogma et al., 2002).

The above hypotheses were examined in a European Union project[7] and reviewed, criticised or edited in some other studies. These studies encompassed empirical (case) studies of completed and/or on-going experiments in a series of fields, from transport to energy to agriculture and sanitation, mainly in European contexts, but also in Tanzania and South Africa (see for instance, Caniels and Romijn, 2007; Van Eijck and Romijn 2008; Lopolito et al. 2011). Some of them examined if the recognized success conditions would have been able to justify the outcomes. The selected case studies involved some examples of market niche development, but many of them showed a limited outcome in terms of boosting further niche development into a sustainable path.

Some other studies emphasize weaknesses of the SNM approach as defined in Kemp, Schot, and Hoogma (1998) and Hoogma et al. (2002). For example, Brown et al. (2004) and Harborne et al. (2007) pointed out that participation of external actors and second-order learning do not occur certainly and by themselves. It requires the presence of particular drivers and circumstances. They point to the importance of a sense of urgency and the role that a process of structured repeated visions might play. Similarly, Hegger and van Vliet (2007) state that the major focus on experiments with technological enhancement in many demonstration projects gives not rise to broad learning and outsider involvement. They suggest redirecting the focus of niche experiments towards concepts, visions and guiding principles rather than on defined technologies, and toward experimentations with social aspects and acceptance before without neglecting the socio-technical character of the transition process. Against this background, the transition management (TM) approach, which will be discussed thereafter, supported by Rotmans, Loorbach and others might help to overcome some weaknesses by integrating the SNM approach. In facts, TM highlights either the

[7] In 1998, the European Union funded a SNM research project within the "Environment and Climate" RTD programme. Through this project, scholars in several countries contributed on SNM. They investigated fourteen innovative transport projects in different European cities (ranging from electric vehicles to car sharing schemes). This collaborative project resulted in a workbook for practitioners on how to do SNM (Weber et al. 1999), and an academic book (Hoogmaet al. 2002).

importance of experiments than the necessity of creating visions before starting experiments (Rotmans et al., 2001; Loorbach 2007).

4.3.3 Transition management

Transition management (TM) matches the study on technological transitions with insights from complex systems theory (e.g., Kauffman, 1995) and governance approaches (Rotmans et al., 2001; Smith et al., 2005). TM scholars have provided and applied an instrumental, practice-oriented model for influencing on-going transitions into more sustainable directions by combining long-term thinking with short term action (thus complementing conventional policy) through a process of searching, experimenting and learning. It is innovative for two orders of reasons: It offers a prescriptive approach toward governance as a basis for operational policy models, and it is explicitly a normative model by taking sustainable development as long-term goal (Loorbach, 2010). According to Loorbach and Rotmans (2006), the TM key aspects are:

- continuous processes of experimentation and learning to address variations and selections along the transition process (learning-by-doing and doing-by-learning) while not chasing "silver bullets" (thus keeping all possible options in consideration and the field open);
- consideration of all possible actors (stakeholder from multiple domains and levels) obtaining input through their inclusion and involvement;
- complementation of conventional policy (which typically has a short-term focus) with long-term thinking with the aim of sustainable development by creating required expectations before starting experiments;
- continuous analysis of the feedbacks (monitoring, evaluating, improving) on all levels in order to bring system innovation alongside system improvement.

The scholars' challenge has been to translate these theoretical aspects into a practical management framework without losing too much of the complexity and, at the same time, without becoming too descriptive. Loorbach and Rotmans (2006) and Loorbach, (2010) tried to develop a framework for transition management by combining practical experiment and real observation. Namely, it is based on "usual" processes of governance that can be seen in society (see, for instance, Kemp 2006 and Parto et al. 2007) but it is structured and distinct on the basis of the characteristics of complex societal transitions. In the transition management

framework, four different governance levels (alternatively called "spheres") are recognized to be significant for sociotechnical transitions (Loorbach, 2010):

- *Strategic level*: a transition arena, a small network of strategic discussions, long-term goal formulation, collective goal and norm setting, and long-term anticipation. Simply, all activities and their developments that deal mainly with the ethics of a societal system as a whole: debates on norms and values, identity, culture, sustainability and relative importance for society.
- *Tactical level*: steering activities regarding the dominant structures (regime) of a sociotechnical system. This includes all established patterns and structures, such as rules and regulations, institutions, organizations and networks which allow to implement a transition agenda towards the desired goal with the consent of regimes, by aligning them with the long-term goal.
- *Operational level*: experiments and actions that are identified by a short-term horizon and carried out in the context of innovation projects and programs, in business and industry, in politics or in civil society to stimulate learning and thus to enable adaptations in transition pathway.
- *Reflexive level*: reflexive activities relate to monitoring, assessments and evaluation of on-going policies, and on-going societal change. In part, they are located within existing institutions established to monitor and evaluate, but in part they are also socially embedded: The media or internet, for example, have an important role in influencing public opinions and judging the effectiveness of policies and political agendas.

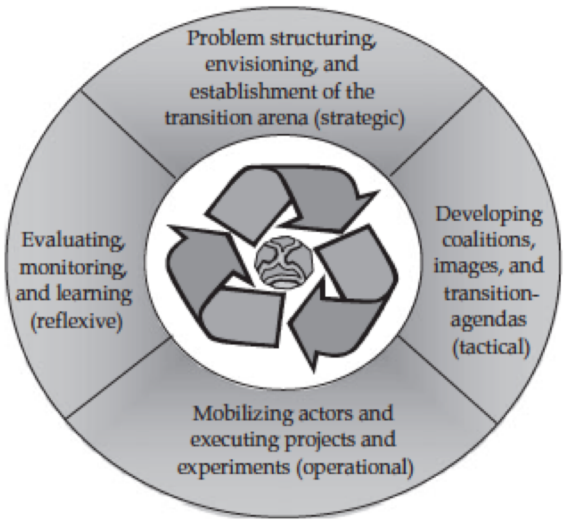

Figure 4. *Transition Management Cycle (Loorbach, 2010).*

The three levels described above follow a cyclical path (Fig. 4) consisting of problem structuring and envisioning (strategic level), agenda building and networking (tactical level), experimenting and diffusing (operational level), evaluating, monitoring, and learning (reflexive level) (Loorbach, 2010).

The transition management framework offers the basis for managing transitions in an operational sense. Although every transition management process will be unique in terms of context, actors, problems, and solutions, the cycle is flexible enough for adaptation but direct enough to be functional in practice. An integrated analysis of a societal system in transition terms yields a very general idea of the dynamics in society on different levels that are a starting point for governance (Loorbach and Rotmans, 2006).

A further theoretical tool that is attracting more attention about the TM approach is the "transition scenario" that is a description of reasonable developments that follows a possible end-state. Transition scenarios help to predict abrupt deviations from trends, align and involve multiple stakeholders, keep options open, and contribute to learning (Sondeijker et al., 2006; Wiek et al., 2006). The methodology to comprehend transition scenarios is identical to the traditional scenario planning methodology (Lachman, 2011).

So far the concept of transition management has been received as promising and pointing into the right direction and has been applied quite extensively in the last decade. However, transition management is not exempt from criticisms. An overall criticism that arises in literature regards the one crucial point of transition management. That is, the claim that deliberate and systemic intervention in pursuit of sustainable goals is possible and potentially effective. Research on historical transitions shows, however, that several transitional changes were unplanned or not originally predicted ('spontaneous change'). But, as Meadowcroft (2007) says, this does not mean that addressing societal processes in order to achieve required changes is unlikely. Conversely, policy makers have often focused on and influenced transition processes, e.g. in the fields of energy, waste, agriculture and water (Loorbach et al., 2007), but typically on a smaller and more modest scale than the one proposed by transition management. Another sharp criticism was proposed by Shove and Walker (2008) who rejected the basic idea of TM as a tool able to explain that a transition can be accomplished mostly through the execution of proper management, so that transitioning is purely a managerial task. By claiming that TM

scholars simplify the scope of the transition task by neglecting the fact that influences exist – both inside and outside the transition management context – such as belief systems, political interests, and culture, which hinder or even prohibit managing transitions according to best management practices and rules. Finally, another criticism that has been advanced pertains to the bias towards the incumbent regimes actors that recognizes little importance to the actors on the niche levels. This is evident in the lack of tools, practices, models etc. employed to empower niches in order to break through into the mainstream (i.e. the regime level) (Kern and Smith, 2009).

4.3.4 Technological innovation systems

Research on technological innovation systems (TIS) has developed constantly during the last twenty years to the point of becoming the fourth major line of analysis in the arena of transition studies. The TIS is an approach developed within the scientific field of innovation studies which serves to explain the nature and rate of technological change and can be defined as a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology (Carlsson and Stankiewicz, 1991). TIS can be described as the combination of all institutional and socioeconomic structures that affects both the direction and the speed of technological change in society. Therefore, the central idea behind this approach is that determinants of technological change are not only to be found in individual firms, in research institutes or in policy intervention, but also in a broad societal structure in which firms, governments, as well as knowledge institutes, are embedded (Hekkert et alt., 2007).

Since these early days, the TIS approach developed numerous theoretical refinements (Carlsson et al., 2002) and one of the most significant has been the specific identification of key processes, so-called functions, which need to occur smoothly for the system to perform well (Bergek et al., 2008; Hekkert et al., 2007). Recently, TIS studies have moreover, developed a greater focus on specific technologies (Hekkert et al., 2007), which is different from prior studies that considered generic technologies at the core of the analysis. This shift in focus is accompanied with greater attention to radical (and often more sustainable) innovations in an early stage of development with a potential to challenge established

socio-technical systems. In other words, the analytical interest has shifted from technological innovation contributing to the economic growth of countries to new technologies as cores for fundamental sociotechnical transitions (Markard et al., 2012).

The main TIS's idea is to "decompose" technological systems in order to split every single component and by analysing them to discover which system elements do not accomplish their intended purpose, thereby hindering the development of the whole system (Jacobsson and Bergek, 2010). The system components of TIS are called structures. These represent the static aspect of the system, as they are relatively stable over time. Three basic categories are distinguished (Hekkert et al., 2007):

- **Actors:** They involve organizations contributing to a technology, as a developer or adopter, or indirectly as a regulator, financier, etc. It is the actors of TIS that, through choices and actions, actually generate, diffuse and utilize technologies. The potential variety of relevant actors is enormous, ranging from private actors to public actors, and from technology developers to technology adopters. The development of TIS will depend on the interrelations between all these actors. For instance, entrepreneurs are unlikely to start investing in their businesses if governments are unwilling to support them financially.
- **Institutions**: Institutional structures are at the core of the innovation system concept. It is common to consider institutions as "the rules of the game" in a society. A distinction can be made between formal institutions and informal institutions, with formal institutions being the rules that are codified and enforced by some authority, and informal institutions being more tacit and organically shaped by the collective interaction of actors.
- **Technological factors**: Technological structures consist of artefacts and the technological infrastructures in which they are integrated. They also involve the techno-economic workings of such artefacts, including costs, safety or environmental sustainability. These features are crucial for understanding the feedback mechanisms between technological change and institutional change.

The structural factors are merely the elements that make up the system and the basic idea of this approach is to consider all activities that contribute to the development, diffusion, and use of innovations as system functions. Therefore, TIS

follows the same approach of the "reverse salient"[8] introduced by Hughes (1983) and used in the Large Technical Systems approach. In other words, technological systems may refer to a hierarchically nested structure of technological parts, whereby the system is seen as a composition of interdependent sub-systems that are themselves systems including more sub-systems. Moreover, technological systems might be seen as socio-technical systems that include, in addition to technical sub-systems, social sub-systems, such as the planner and material creators of technology and its users, as well as the supervision of regulatory subjects. This makes the approach very interesting for policy makers because it allows identifying at each level a possible bottleneck in transition processes. In fact, from their beginning, many analyses of technological innovation systems were intended to actively involve policy makers in the identification of drivers and barriers to innovation systems (Negro and Hekkert, 2008). In this context, one of the major contributions of the innovation systems perspective is that it has left behind the narrow concept of market failures and replaced it with a broader set of system failures, involving weakly working networks, institutional failures, infrastructure failures, etc. (Bergek et al., 2008). This, combined with the above-mentioned change of focus toward technology-specific innovation systems, has paved the way for suggesting technology-specific policies on the basis of TIS studies (Jacobsson and Bergek, 2011).

Despite the importance and attention achieved by the TIS approach, it has not been without criticism on transition dynamics. First of all, as claimed by Geels (2011), it is a multi-dimensional approach (although cultural and demand side aspects are under-developed), which does not address structural changes and do not look at interactions between new entrants and incumbents, but tend to focus only on technology and market dimensions (for instance, in terms of how emerging innovations struggle against existing systems). Secondly, it focuses more on the functioning of systems, particularly, in discovering the weaknesses of elements, rather than overall system changes. Therefore, mostly of emphasis is given on identifying system weaknesses, neglecting oftentimes their development and the reasons behind these weaknesses. As a consequence, a little attention is given to system dynamics (Smith et al., 2010). Finally, TIS approach place more focus on

[8] Thomas P. Hughes introduces the concept in the analysis of technological systems, whereby the reverse salient refers to a component of the system that, due to its insufficient development, prevents the technological system in its entirety achieving its targeted development.

powerful actors, such as institutions and firms, and tends to neglect smaller one, such as grass roots movements and individuals (Geels, 2011).

Although these criticisms, the TIS approach has been strongly developed by some scholars, in particular in the 1990s, and has become one of the strands of research on (sustainability) transitions (Alkemade et al., 2011), even if it is argued that it has not evolved into a broader understanding of transitions (Smith et al., 2010).

4.4 General critique

Despite the approach-specific considerations and limitations that have been emphasized in the section above, there are some important aspects concerning in general the theoretical approach of transition to be considered. These considerations needs to be taken into account in order to optimize and to update the proposed approaches by making them more inclusive, applicable for different backgrounds, appropriate for a broader focus regarding transitions, or at least make users aware of the weaknesses that are intrinsic to these approaches. A set of general and critical considerations concerning the approaches studying (sustainability) transitions are reported hereafter.

- Approaches investigating transitions are profoundly characterized by the ambit in which they were envisaged and could, hence, be less appropriate for other environments. A clear issue concerning such limitation is the substantial difference between so-called developed and developing countries (Lachman, 2013); they diverge on social, behavioural, environmental and political aspects. An example is the fact that in developing countries the best part of technology, if not all, is not domestically developed, but rather imported from developed countries. As a result, the knowledge at the base of the technology often does not follow the technology, but rather remains "locked" in the country of origin. An additional example can be found in the rapid rate of development, population growth, and urbanization in developing countries that straightens other relevant objectives for policy makers (i.e. employments, standards of living, etc.) rather than transition toward sustainability, thus implicitly reinforcing current regimes to a degree that is hardly the case in developed countries. These cases show that context-specificity can have a remarkable effect on the success or failure of a transition; thus, even if notable efforts has been provided, from scholars, in the field of energy system transitions and important research achievements have come

to light, it should be noted that studies on transition have been largely addressed and confined to its origin, that is, in developed countries, and hence approaches to investigate these transitions originated in developed countries should therefore be tested in other geographical and socio economical contexts and be adjusted consequently. It is important to report here that some studies have been carried out in specific Asian developing countries (Berkhout et al., 2010; Rehman et al., 2010; Romijn et al., 2010; Verbong et al., 2010), but these cannot be considered representative for other countries outside the Asian context.

- Approaches analysing transitions also suffer from a strong bias towards producers/suppliers perspective (Verbong et al., 2008). Focus is heavily linked to the innovation-process; see for example the meanings that have been assigned to the niche-concept, only (lately) broadened in scope by Geels (2007). Consequently, attention is almost entirely dedicated to producers, suppliers and institutional networks, while transitions concerning mainly the activities related to consumer/user are much less considered. Against this background, there is an open ground that needs to be filled in since one of the most salient aspects regarding sustainability transitions is the fact that, in order to achieve the target of sustainable development, existing modes of production and consumption (in particular regarding energy resources, food and water) are earnestly in need of a shift toward sustainability.

- The application of the approaches appears, in some circumstances, quite complex and lacks in consistency. To have an idea, in a survey of the transitions literature, Raven et al. (2010) found five different meanings of the regime concept, six different meanings of the niche, and four different meanings of the landscape. Genus and Coles (2008) have found, for example, that MLP is applied unsystematically across different studies and that transitions researchers repeatedly omit justification of choices and interpretations. At the same time, the unit of analysis is far from clear in the theory and involves both strategic choices and political decisions (Walker and Shove 2007). Therefore, an effort should be made by researcher in order to have a unity of purpose, a clear justifications and definition of the aforementioned sociotechnical elements.

4.5 Strengths, contributions and potential lines of future research

Apart from the aforesaid general critiques on transition research, there are some important strengths and contributions that need to be emphasized and which create the bases for further developments of this field of research.

As mentioned in section 3 above, some studies conducted over the last years helped expanding the scope of the research on transitions with regard to developing countries. Although still at an early stage, a growing number of transition studies in developing countries are carried out by scholars from developing nations, which are currently contributing with their research by developing transition models and implementing transition experiments, etc. This is the confirmation that sociotechnical transition toward sustainable future is being increasingly considered worldwide.

An important contribution from transition research to highlight is the fact that transition scholars are open to venture into uncharted territory by applying transition thinking in different disciplines and using ideas and concepts from these disciplines to advance transition thinking (Geels, 2010). Some examples are insights from social movement theory and political science used to deepen the Multi-Level Perspective (Elzen et al., 2011), the steps taken to link transition thinking in urban and spatial planning (Coenen et al., 2012; Hodson and Marvin, 2010) and in some health policies (Morone et al., 2013). Such openness and dynamism makes researcher free from the risk to be trapped in their own discipline while analysing transitions. The possibilities to interact with other disciplines are practically infinite, and the fact that transition scholars seek to synergize with other subjects is an explicit advantage to exploit for future development of this field of research.

4.5.1 Major lines of future research in transition studies

This subsection considers four wider lines of potential research on sustainability transition studies that we derived from the analysis of the literature on the topic, including several special issues, e.g., Smith et al. (2010) and van den Bergh et al. (2011), and the manifest of the STRN network (STRN, 2010) and aim at providing a fertile ground of investigation as well as a solid framework for future analysis.

First, there is a specific necessity to think out and better specify the theoretical frameworks and methodological foundations for comprehending both historical and

current transitions. This implies to challenge the prevailing theoretical approaches in terms of where and how they can be implemented, which are their constraints, up what ontological considerations they are grounded, etc. Against this background, there have been some recent discussions on the strengths and weakness of the multilevel perspective approach (Geels, 2011; Markard and Truffer, 2008), which not only allows making the framework more accurate and reliable, but might also conduct to a more exact application in empirical analyses. Moreover, we believe that there is a lot to know from established ideas and frameworks in other disciplines and such additional knowledge could be used in a complementary way to provide more consistent explanations. Consequently, enhancements in the conceptual approaches on transition studies will have implications for the methodological styles that will be prevalent in transition research as well.

Second, considering the importance in nowadays transitions of transition-based policy concepts, such as strategic niche management or transition management, there is a critical need to better understand the role of the politics and policies on sustainability transitions processes. Conceptually, topics concerning the power and politics have initially been quite neglected (Meadowcroft, 2009; Shove and Walker, 2007). Only lately these issues began to be fairly considered given that they represent quite an important line of research activity in transition studies (Avelino, 2011). At a more operational level, further research is required to better understand and specify the long-term effects of specific policies on sustainable transitions in order to develop and and implement of new policy frameworks to make transition activities carried out at different levels more effective.

A third domain in which further research appears to be quite promising relates to the understanding of the agency of different actor groups in the context of transition processes (Raven et al., 2011). Strategies of firms and other actors or the role of strategic unions within industries did not collect the necessary consideration in the existing body of literature on socio-technical transitions. While green innovation is one of the core drivers for fundamental shifts in industry structures, transition research has predominantly focused on meso-level contexts, such as innovation systems and sociotechnical regimes neglecting, for example, the role of civil society and cultural movements in transition processes. Therefore, the field might benefit from more in-depth studies on how system and regime structures are created and

changed through the strategic interplay of different types of actors at each level (Musiolik and Markard, 2011).

Finally, there has been an increasingly attention over the past few years in addressing more explicitly the geographical dimension of historical and emerging transition processes (Coenen and Truffer, 2012). This will have implications on the conceptual level of the transition approaches, i.e. by addressing the differentiation of regime, niche, and innovation system structures in particular regions of the world. It also has strong empirical implications in that transition processes happening in developing countries that have not received, to this point, adequate attention in the literature, and their inclusion may require further conceptual work. Therefore, more research is needed on transition approaches - and their suitability - in developing economies that perhaps are the most needy of transition towards sustainable futures.

Addressing these issues more explicitly would eventually enable the analysis of transition processes and the specification of related approaches in a truly "global" perspective, which is what many of the global environmental change problems, such as climate change or biodiversity management, ultimately will require (Coenen and Truffer, 2012)

4.6 Conclusions

Sustainability transition arena represent a fertile ground for research, given the importance and indispensability of sustainability challenges we are facing today. It has evolved quite notably in last years, with a sharp increase of the number of papers published, special issues on a variety of subtopics, and the development of institutional structures, such as the STRN network, fostering the establishment of a research community. However, sustainability transition is a field manifold because of the large number and variety of actors and interests concerned in transition processes.

This chapter tried, in the hopes of the author, to provide a description of the most relevant theories and approaches to understand and elucidate (sustainability) transitions and key related concepts. At this end, the work has a critically reviewed the transition theoretical approaches and related dynamics separately, providing on the one hand, both some general and specific criticism and, on the other hand, highlighting important strengths, contributions and potential line for future research.

We believe that improving conceptual and methodological approaches is one important issue on the research agenda, but providing further empirical insight is

certainly another. Therefore, there is still some significant work that needs to be done, and fortunately the open and dynamic nature of transition research makes it possible to adopt ideas to develop the transition research field by enlarging the focus in other disciplines and context (i.e. developing countries). This is very promising and transition researchers must consider such possibility, not only to understand sustainability transitions, but also to find a way to affect them in order to mitigate the impacts resulting from the on-going climate change.

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5. Social network analysis of the bio-waste technological niche. A focus on bio plastic production. *Evidences from Italy*.

1. Introduction

Over the past decade, with global climate change challenges and its various effects on ecosystems and on resource depletion, the waste problem has received increasing attention. In particular, there is a general consensus that a holistic approach to waste management has positive consequences for GHG emissions, as the prevention and recovery of waste (i.e. as secondary materials or energy) helps reducing emissions in all other sectors of the economy – agriculture, mining, transport, and manufacturing (UNEP, 2010: 4).

In addition, the increasing costs of fossil-based raw materials and the need for more efficient and environmentally friendly production patterns (in line with the goals of sustainable development) led to a search for alternatives, namely finding possible ways to obtain chemicals, fuels and solvents from other sources, such as biomass streams.

These global trends exert a significant pressure upon the dominant technological regime – i.e. the fossil-based economy – and might eventually foster a sustainability transition towards a bio-based economy. However, for such a transition to occur, an alternative technological niche has to be sufficiently developed. In fact, the multi-level perspective argues that transitions come about through interactions between processes at three levels: (a) niche-innovations build up internal momentum, (b) changes at the landscape level create pressure on the regime and (c) destabilisation of the regime creates windows of opportunity for niche-innovations. The alignment of these processes enables the breakthrough of novelties (Geels and Schot, 2007: 400).

Although, in the last ten years the potential of bio-based production of chemicals and materials has been documented by several studies, the investment in industrial biotechnology and bio-refineries across Europe is still at a low level (Carus et al., 2011). Moreover, most of the efforts in this very area have been channelled towards

the production of bio-based products that make use of raw materials obtained from dedicated cultivations as opposed to raw materials obtained from waste valorisation processes. We believe this latter approach is by far more promising. Although first generation food waste recycling (e.g. anaerobic digestion, composting, animal feed) have only marginal economic value, more recent food supply chain waste (FSCW) valorisation aimed at producing products such as materials, fuels and chemicals represents one of the most promising research avenues from both environmental and economic standpoints. In this regard, the valorisation of waste has many advantages, but mostly it solves a waste management issue and represents a sustainable renewable resource, making it doubly green.

In this chapter, we concentrate on the bio-waste technological niche development and on its role in the sustainability transition towards a bio-based economy (i.e. an economy which makes the most out of biomasses in terms of energy and production of other by-products). As we believe, this very area of enquiry is still under-investigated and its applications are under-appreciated both from a theoretical point of view and from an industrial applied perspective. Thus, through our research study we aim at providing insights into the potential development of the bio-waste technological niche and into factors that may hinder the full development of such technological niche.

The chapter is structured as follows: in Section 2 the motivation and the research questions are briefly depicted; in Section 3 the methodological framework is explained. Section 4 is divided into two sections, namely in section 4.1 the case-study designed to investigate the development of the bio-based technological niche (i.e. bioplastics shopping bags derived from bio-waste valorisation) is outlined, and in section 4.2 results are presented. The research implications and concluding remarks are highlighted in section 5.

5.2 Motivation and theoretical framework

Approximately 120 to 140 million tones of bio-waste are produced every year only in the EU and about 40% of this entire amount is landfilled – up to 100% in some Member States (EU, 2011). As a consequence, making the bio-waste handling more environmentally friendly has become a key objective for policy makers.

Across the world, the most used practices to treat urban bio-waste are anaerobic digestion and composting, allowing the re-use (complete or partial) of the waste at the end of the treatment process. However, these techniques lead to low value products and as a matter of fact, more advanced technologies (through the identification and isolation of valuable components present in the bio-waste streams) could offer the potential to recover higher value products for use in chemical, agriculture, pharmaceutical or other industries (D'Hondt and Voorspoels, 2012; Montoneri et al., 2011). Therefore, the focus should be shifted to a better exploitation of this specific type of waste that is largely unavoidable.

Urban bio-waste valorization for the production of higher value and marketable products (e.g. bio-surfactants, bio-solvents, bio-lubricants, etc.) requires both new forms of production technologies and new scale-efficient product supply chains development. These new demands intensify the interaction between various actors of the supply chain, for instance, between owners of waste treatment plants and potential investors from other industries. However, since the bio-waste technological niche is not fully developed (in some cases it is still in the laboratory stage), its future outcome is characterized by different degrees of uncertainty and risk, both at macro and micro levels: on the one hand, there is the problem of funding instability – i.e. the need of large investments to make the shift from laboratory to industrial scale, coupled with uncertainty on technology performance, uncertainty related to the potential market size, uncertainty related to the challenge of technical scale-up and the need to set new, complex value chains which require a long term-perspective. On the other hand, there is a wide range of stakeholders who have different levels of expertise and knowledge that can lead invariably to different ways of understanding the decision making process.

Grounded on these considerations, this paper aims at investigating the Italian bioplastics sector,[9] assessing its potential to develop into a mature technological niche. Specifically, while looking at bioplastic producers, we concentrate our attention on production technology based on urban bio-waste valorization (as opposed to bioplastic produced through dedicated crops) as we believe this is the most promising technology leading towards a double green transition. Hence, in our investigation, we consider the

[9] Specifically, we are analysing the bio-plastics shopping bags production niche.

fossil-fuel production technology as the dominant technological regime, and the bio-plastic based on bio-waste, as the most viable emerging technological niche.

Building on this assumption, we assess the potential development of bio-plastic derived from waste within the framework of strategic niche management. Specifically, we focus on three key niche mechanisms: (1) expectations, (2) learning process and (3) network formation (see Kemp et al. 1998 and Lopolito et al. 2011).

Articulating expectations is important to attract attention and resources as well as new actors, in particular when the technology is still in early development and functionality and performance are still unclear. Expectations also provide direction to development: they act as cognitive frames for making choices in the design process. Upward convergence of expectations requires that (a) an increasing number of actors share the same a common positive view on the niche technology, and (b) the expectations are based on tangible results from experiments (Kemp et al. 1998).

The second mechanism identified (learning process) is widely recognized as crucial for successful innovation (Kemp et al. 1998). Learning will occur both individually (as producers will increase their knowledge simply ‘‘by doing’’) and collectively. This latter option implies that firms and other stakeholders involved in the technological niche, will share the possessed knowledge (Lopolito et al., 2011).

The third mechanism is the building of social networks. In particular in early phases of an innovation’s life cycle, the social network is still very fragile. Building social networks is effective for niche development when (a) the network is broad (including firms, users, policy makers, scientists, and other relevant actors), and (b) when alignment within the network is facilitated through regular interactions between the actors (Kemp et al. 1998). Moreover, considering the niche as a small network of dedicated actors, the architecture of the social network (density of relations, centrality of key actors, etc.) might turn to be very relevant for the health development of the technological niche.

While building on these methods, we shall revert their order, as we believe that convergence of expectations and learning processes depend significantly upon the network formation and more on its structure. A similar view was first taken by Caniëls and Romijn (2008), who investigated the link between networking and learning as well as the link between networking and the formation and convergence of expectations. A key aspect, in this regard, is the importance of durable interpersonal

relations such as friendship ties that facilitate both informal learning processes and expectations convergence. Along this line or reasoning Hermans *et al.* (2013) showed in a recent study, how the structural characteristics of the network of a technological niche are positively related to the building of trust as a result of successful experimentation. In the authors' words, successful experiments not only increase the size of the network but also increase its connectedness.

Bearing this in mind, we concentrate on three main research questions, namely: (1) What are the structural characteristics of the Italian bioplastics network? (2) What is the social network architecture? (e.g. Is the network characterized by one or more star agents? Is it a full network? What is its degree of connectivity?) (3) How does the network architecture affect expectations' formation and learning processes (knowledge flows)?

Once addressed these three questions, we shall focus on the implications for the further development of the bioplastics (derived from bio-waste) niche and, more generally, for a permanent shift towards a bio-based economy.

5.3 Methodology

In order to address the above mentioned research questions, social network analysis (SNA) is used, as it allows to: (i) identify the key actors forming the social network, (ii) investigate the network architecture's properties, and (iii) identify opportunities and obstacles to expectations' convergence and learning processes.

Social networks and social network analysis, in fact, are fields of increasing interest among social scientists. Much of this interest is attributed to the relationships among social actors and to the patterns and implications of these relationships on the economic, political and social environment.

The core unit of analysis is, of course, the social network defined as "a specific set of linkages among a defined sets of persons with the additional property that the characteristics of these linkages as a whole may be used to interpret the social behaviour of the persons involved" (Mitchell, 1969: 2). That is, "a social network consists of a finite set or sets of actors and the relation or relations defined on them" (Wasserman and Faust, 1994: 20).

Some relevant basic concepts of network analysis worth mentioning are: (*i*) actors and their actions are viewed as interdependent rather than independent units; (*ii*) relational ties between actors are channels for transfer or *flow* of resources (knowledge and expectations, in our case); (*iii*) network models focusing on individuals view the network structural environment as a source of opportunities for or constraints on individual action; (*iv*) network models conceptualize structure as lasting patterns of relations among actors (Wasserman and Faust: 1994).

The method of social network analysis provides an explicit formal way of measuring social structural properties (referred to actors in a given set). In other words, this tool seeks to model the relationships among a set of actors to describe the structure of the group. In this sense it is a valuable tool for studying articulated firms and institutional networks such as the one of bioplastic shopping bags producers investigated in this paper.

The network analysis method combines two different literatures, that on graph theory and that on matrix algebra.[10] This allows researcher to represent information about patterns of ties among social actors and enables to represent the structure of a system and describe it as a set of interconnected elements. Moreover, using these tools will allow us to evaluate and measure social relations, information and knowledge flows among individual actors, groups and Institution.

The graph theory approaches a social network as a social system model consisting of a set of actors and the existing ties among them. For the purposes of this paper, the social network is structured as a network graph consisting of nodes (vertices) and connections (edges). In other words we could define such network as a "nonempty set of elements, called vertices, and a list of unordered pairs of these elements called edges" (Wilson and Watkins, 1990). In our analysis vertices correspond to firms (classified as producers and suppliers) or Institutions and edges are the existing connections. Formally we have G (I, Γ), where $I = \{1, \ldots, N\}$ is the set of vertices, and $\Gamma = \{\Gamma_i, i \in I\}$ gives the list of vertices to which each vertex is connected.

The graphical display may prove to be inadequate with a growing number of actors and relations. Therefore, in order to get more specific information on the nature of relations and on the network properties a matrix analysis would be a more useful tool

[10] The conjoint use of both of the techniques is required to avoid, as it is likely to happen, graphs of different shapes generated by the same matrix.

(Maggioni, 1994). The mathematical base of the graphical construction is socio-matrix. The two dimensions of the matrix are indexed by the sending actors (the rows) and the receiving actors (the columns). A socio-matrix for a dichotomous relation is the *adjacency matrix* that quantifies the ties between the actors. That is, a two dimensional matrix in which the generic element a_{ij} = 1 if among actors i and j a relation exists, and a_{ij} = 0 if not.

When studying social networks, we must consider the fact that fully saturated networks are rare, particularly where the population consists of more than a few actors. In this regard, it will be useful to look at how close a network is to realizing this potential. For example, the *density* of a sociomatrix is defined as the ratio of actually present ties to all possible connections. This index goes from *1*, if all possible ties are present, to *0*, if there are no lines present. It could be calculated as $\Delta = \frac{L}{\frac{N(N-1)}{2}} = \frac{2L}{N(N-1)}$, where Δ is the density of the graph, L the number of lines in the set and g the number of actors or nodes. Another property is *inclusiveness*: it refers to the number of points that are included within the various connected parts of the graph. That is the total number of nodes minus the number of isolated points. The most useful measure of inclusiveness for comparing various graphs is the number of connected points expressed as a proportion of the total number of points. An isolated vertex is a node with no connections; hence it has nothing to contribute to the density of the graph. Therefore, the more inclusive is the graph, the denser it will be. We shall further look at *cut-points*. A cut-point is a pivotal point of articulations between the elements that make up a component.[11] Cut-points indicate some kind of local centrality and the absence of cut-points implies that communication and exchanges among the members of a component are not dependent upon any one member (Scott, 1991). Hence, the presence of cut-points may jeopardise communication and exchange, as their removal disconnect the component (or the graph).

Furthermore, networks can have one or more kinds of relations existing between pairs of actors. To enhance our understanding of social networks we shall extend the analysis to another variable such as the nature of relations between actors. We can have, and this is true especially for firms, more than one kind of socio-economic

[11] A component is a portion of the network composed by a set of actors who are all connected (i.e. all nodes in the subgraph are reachable from all other nodes in the subgraph).

relations, as they relate to different kinds of exchange (Lomi, 1991: 48). In order to deal with this further complication we shall consider *multi-relational networks*, distinguishing among a generic type of interaction (this will allow us to build the 'who knows who' network) and more specific type of interactions involving the exchange of expectations, information and/or knowledge. Moreover, networks can be characterised by single or multiple *attributes* associated to each node of the graph. In our case we shall concentrate on two attributes, namely the knowledge level and the expectation level. There is a growing body of literature investigating the effect of social networks on the evolution of population attributes, which occurs as agents interact via the network. In a recent paper Brueckner and Smirnov (2007) developed a formal model in which they demonstrate how attributes converge to a melting-pot equilibrium (where everyone is identical in terms of their attributes), provided the social network exhibits a sufficient degree of interconnectedness.

5.4 Case study

In the context of growing demand for more sustainable solutions, the EU Commission identified the bio-based products sector as being of high societal and economic interest and pointed at bio-plastics as a main driver for the achievement of the sustainable goals of EU 2020. Thus, over the last years several strategies at the EU level have been developed,[12] establishing bio-plastics as a key driver for more sustainable economic development (European Bio-plastics, 2013: 1).

In line with the EU Commission vision, Italy is currently trying to develop a strong bio-plastics sector,[13] triggering private investments in new plants (see Figure 5), aimed to lead to new jobs[14] and local growth. In order to foster the development of the bioplastics sector, the Italian legislative framework has undergone some changes over the years. Currently, the main legislative acts in place are: **DL152/2006 -** according to which the organic waste has to be collected either in biodegradable and compostable bags (compliant with the harmonised CEN Standard 13432) and paper bags or in bins;

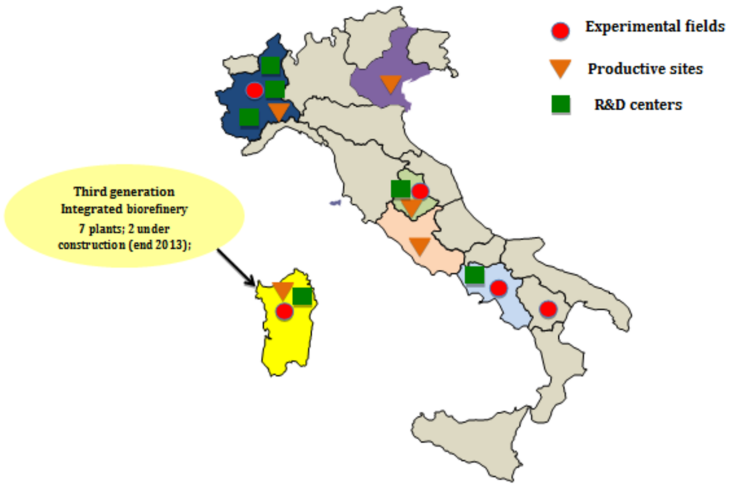
[12] Lead Markets Initiative for Biobased Products, Resource Efficiency Strategy, Key Enabling Technologies, FP7 & Horizon 2020, Bioeconomy Strategy, Waste Management Framework, etc.

[13] The starting raw materials are derived from dedicated crops (e.g. maize) as well sugars or starches, and partially also recycled materials from wood processing.

[14] According to PlasticConsult Study, Italian producers of films and biodegradable compostable bags have increased their labour force by 3% in 2011, creating directly about 500 jobs. In addition, through the Matrica Project – the third generation biorefinery (located in Porto Torres - Figure1) will directly employ about 680 people, generating significant direct and indirect effects on the local areas.

2007 Finance Act[15]- adopted in January 2011 that bans the use of traditional plastic shopping bags, allowing only the shopping bags that are either biodegradable and compostable or reusable; **New law 28, 24/3/2012** – according to which non-reusable shopping bags have to be certified by accredited bodies as biodegradable and compostable according to the European Standard EN 13432.

Figure 5. The Italian Map of Industrial Initiatives related to Bioplastics



Source: Adapted from Bastioli, 2013

However, as a result of exploitation of the loopholes[16] in the initial text of the 2007 Finance Act and the subsequent delay of penalties payment until December 2013, there has been a proliferation of traditional plastic bags claiming to be biodegradable,[17] especially at the level of small Italian retailers but also among 50% of the Italian mass retail market (Ganapini, 2013: 60).

[15] **AssoEcoplast** claims that this law "introduces a strong distortion on the market of plastic packaging in the benefit of a few operators and to the detriment of hundreds of companies operating throughout the country, with more than 10,000 employees, of which at least 5,000 in immediate risk of getting fired, and who find themselves de facto excluded from the market." (AssoEcoplast, 2012).
[16] We refer to the absence of an express reference regarding the compliance with the European Standard UNI EN 13432:2002 on biodegradability and compostability harmonised with the Packaging Directive 62/94.
[17] By means of questionable certifications and self-declarations.

According to the latest available data on the Italian bioplastics sector, there are 93 active companies, 77 of which are primary transformation companies, 16 of which are producers of raw materials[18] (see Table 9).

The Italian bioplastics sector is known especially for biodegradable and compostable shopping bags, but this is not the only niche area. A snapshot of the current bioplastics applications in Italy is provided in Table 10.

Despite the evidence presented in Table 9 and Table 10 and in spite the well-known benefits associated with the development of a bioplastics market, there are some limitations as regards the growth of bioplastics products made from dedicated crops. One of the main constraints refers to the *uncertainty as regards a sufficient supply in the long run for the bioplastics production* – for instance, in Italy, the land dedicated to the production needs of bioplastics based on corn starch is about 0.2% of the total land dedicated to Italian production of corn.

Table 9 – Bioplastics sector – Employment and business volumes in 2012 [19]

Primary transformation companies		**Producers of raw materials**	
Companies active in Italy (no.)	**77**	Companies active in Italy (no.)	**16**
Total biopolymer volume (tons)	**39,250**	Total biopolymer volume (tons)	**39,250**
Biodegradable products sales (€ mln)	**187.1**	Raw materials sales total (€ mln)	**139.6**
Number of employees	**850**	Number of employees	**230**

Sustainable sourcing of feedstock is a prerequisite for the market uptake, for this reason we considered relevant and valuable to assess the potential development of a bio-waste technological niche of bioplastic producers. Currently, bioplastic products derived from dedicated crops or starches, receive a strong support during commercial production whereas necessary instruments such as R&D support, standardization and

[18] Producers of polymers and ready to use compounds, excluding chemical intermediates. Sales companies and agents of foreign producers also included.

[19] http://www.assobioplastiche.org/wp-content/uploads/2013/10/The-Italian-Market-of-Compostable-Bioplastics.pdf, accessed 22.10.2013

information tools are discussed for bioplastics derived from bio-waste valorisation. To this end, the outcomes of Biochemenergy project (funded by the local government of Piemonte region, located in the north-west of Italy),[20] which demonstrated that urban bio-wastes are a rich source of soluble bio-organics (SBO) which may be used to manufacture a large range of bio-based products, are relevant.

Table 10 – Bioplastics applications – Distribution of Italian's Companies

Primary transformation companies (no.)	
Shopping bags	**35 (45%)**
Shopping bags and bags for organic waste collection	**15 (20%)**
Agricultural mulch films, films for food packaging, films for sanitary use, etc.	**10 (13%)**
Other applications –i.e. extrusion coating, masterbatches, etc.	**6 (8%)**
Other injection moulded goods – i.e. blanks for bottles, household objects	**4 (5%)**
Disposables – cutlery, dishes, cups	**4 (5%)**
Bags for organic waste collection	**3 (4%)**
Total	**77 (100%)**

Considering the general context depicted above, in order to identify all the potential members of the Italian bio-waste technological niche of bioplastic producers, we have adopted a snowball sampling methodology. Specifically, following the advice of an expert from Assobioplastiche (the Italian Bioplastic, Biodegradable and Compostable Material Association) we selected a number of actors (any type of stakeholder) who could potentially form the Italian bio-waste-plastic potential niche. Then, the actors named by peers, but not included in the original list of actors, have been added into the network. The questionnaires were administered in two rounds (the first round was in May 2013 and the second round was in September 2013) by means of emails followed by telephone interviews. In this way, we were able to include in the network 66 actors,

[20] See, for instance Montoneri, 2011.

48 of which are firms (producers of bioplastic shopping bags),[21] 9 of which are suppliers of raw material (from chemical industry, these are bot national and international actors)[22], and 9 are institutions (e.g. regional and local authorities, universities, NGOs, etc.)[23].

The questionnaire was structured in two parts. The first part of the questionnaire aimed at gathering general information on the firm or institution as well as their level of knowledge on bio-waste-plastic production and their expectations upon future development of the sector. The second part aimed to collect information on relations and, more precisely, on the existence or not of ties, its nature and, in the case of the existence of a tie, the kind of relation. Specifically, the second part of the questionnaire was composed by four questions: the first one asked respondents to indicate all the actors they know from a predefined list, as well as to point out any other known actor not included in the provided list. A second question asked respondents to identify, among all known actors, those with whom they have established an interaction (of any kind). A third question asked respondents to specify the actors with whom they have established relations in order to exchange information. A forth question concerned the knowledge flow and respondents were asked to indicate the actors with whom they have established relations aiming at knowledge exchange concerning the bio-based products (existing technologies, regulations, public policies, etc.). Hence, we defined the following four types of network: (1) who-knows-who network; (2) interaction network; (3) communication network; (4) knowledge network. Although relevant, the first two networks describe just *potential or generic* forms of interaction. Indeed, communication and knowledge networks are more relevant when it comes to assess the impact of network architecture in boosting expectations' convergence and learning processes.

[21] We decided to concentrate on the plastic shopping bags in order to have a comon denominator across all firms interviewed. The plastic shopping bags sector was selected also bearing in mind also the "push" from the legislative point of view the sector has received over the last few years. Another characteristic of our producers is that most of them are from northern and central Italy and to a lesser extent from southern Italy, a fact due to the low response rate of southern producers.

[22] Suppliers include foreign large chemical industrial players who are investing across Italy (in order to expand the plastic production from renewable resources) as well Italian chemical industrial players. As we noted through a preliminary study of the sector, some of these firms are conducting an "agressive" campaign in order to promote their raw material.

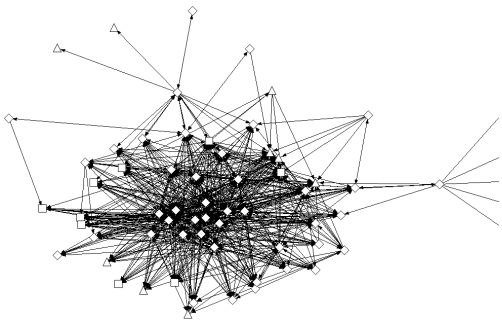
[23] We included in this category: universities (for the moment represented in the network as a single entity, without including in the network specific universities), national and local authorities, professional associations and NGOs.

5.4.1 Results

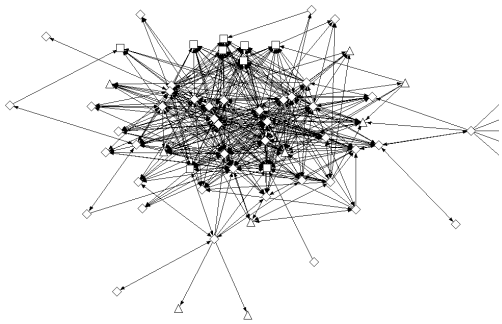
All gathered network data has been organized in the form of full structural network adjacency matrices and processed with the software package UCINET 6 that also allowed us to generate sociograms through its incorporated visualization software NetDraw. We carried out the analysis at two levels: first, we considered the above mentioned four social networks disregarding attributes as we concentrated on the general architectural features of the networks looking at their evolutions when moving from the who-knows-who network to the knowledge network. Subsequently, we concentrated our attention on the communication and knowledge networks considering also attributes and cut-points.

Figure 6. The Italian bioplastic production - multi-relational networks

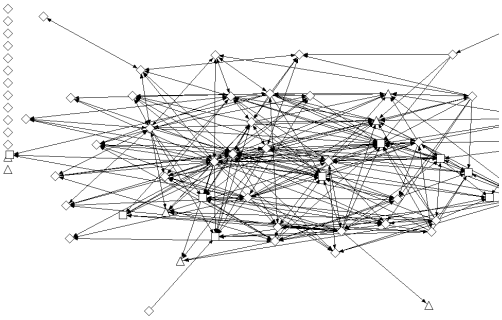
Who-knows-who network



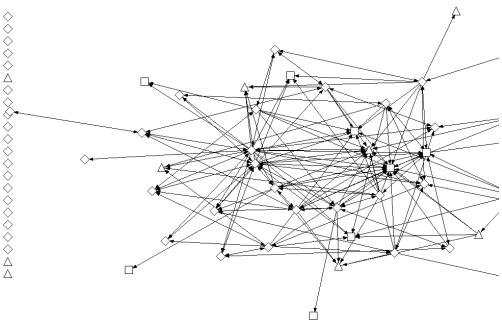
Interaction network



Communication network



Knowledge network



Key: *Diamonds represent Producers; Up triangles represent Suppliers; Squares represent Institutions*

Looking at the four networks reported in Figure 6, the fact that the network density decreases significantly as we move from the who-knows-who network to the knowledge network is immediately noted. This preliminary finding shows how only a small portion of all possible connections is actually used to exchange knowledge directly related to bioplastic production, suggesting that there is a potential for a larger number of interactions which is currently unexploited. This is confirmed in the inclusiveness index (see Table 11) which decreases from 100% to 78.8% in the communication network (with 16 disconnected actors out of 66) and to 66.7 in the knowledge network (with 22 disconnected actors). A similar trend is observable in the average degree as well as in the clustering coefficient (calculated for the overall graph).[24] Nevertheless, inclusiveness and average degree cannot be considered to be low also in the communication and knowledge network.

As observed above, the architectural features of the system change when considering communication and knowledge networks. In this second case the overall structure becomes less connected and less clustered with several firms (mainly producers) disconnected from the central component. Moreover, when it comes to communication and knowledge networks, there are at least three institutions and one supplier gaining a central role in the network. This suggests that, along with a core group of producers, other actors (not directly involved in the production process) play a central role in the knowledge and information exchange.

Table 11. The Italian bioplastic production networks - key indicators

	Density	Inclusiveness	Average Degree	Clustering coefficient (overall graph)
Who knows who network	*0.200*	*100%*	*13.000*	*0.210*
Interaction network	*0.133*	*100%*	*8.636*	*0.162*
Communication network	*0.076*	*78.8%*	*4.924*	*0.087*
Knowledge network	*0.045*	*66.7%*	*2.909*	*0.059*

[24] Note that in the who-knows-who network inclusiveness is equal to 100% by construction. This is not the case for the interactions network.

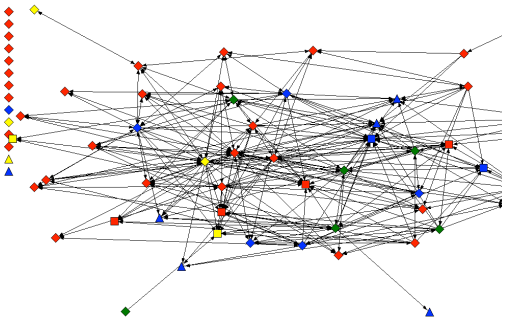
We shall now turn our attention to the attributes' networks. In Figure 7 we report the attributes of communication and knowledge networks related to both expectations and knowledge. At a first glance, we notice that expectations are, on average, lower than knowledge. If we focus first on the communication network and look at the expectation attribute we can observe the presence of a group of actors (both producers and institutions) occupying a central position in the network but with a low level of expectation. This is indeed a critical feature of the network architecture with respect to the convergence of expectations mechanism discussed in section 2 above. Moreover, since these central actors share also a high-medium level of knowledge, this makes the situation even more critical. As it seems, there is a cluster of knowledgeable and well-connected actors, enjoying a central position in the communication network, which share low expectation towards the future development of the technological niche in question. This is a fact that might seriously hinder the full development of the niche, jeopardising the possibility to initiate a sustainability transition towards the production of bioplastic derived from bio-waste valorisation.

A similar picture emerges if we look at the knowledge network. Also in this case we observe a relatively small group of actors with low expectations occupying a central position in the network. Moreover, also for these actors expectation is often inversely correlated with knowledge.

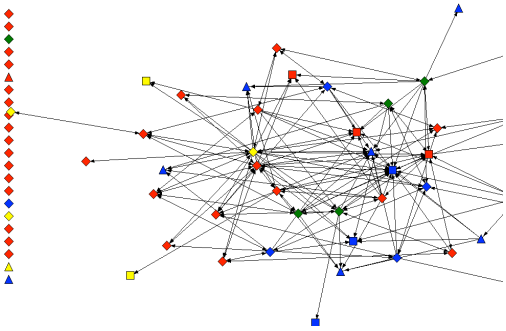
Another important finding emerging from a visual inspection of the communication and knowledge attributes' networks: a relatively large number of highly knowledgeable actors are disconnected from the main component and, therefore, do not contribute to the network development. Again, these "misplaced" resources could potentially contribute to the niche development, but who are, for some reason, impeded in their action by the architectural characteristic of the social network.

Figure 7. The Italian bioplastic production - attributes' networks

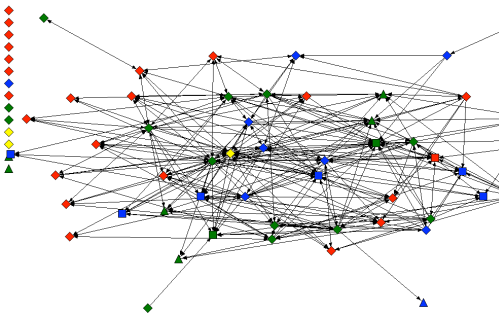
Communication network (attribute: expectations)



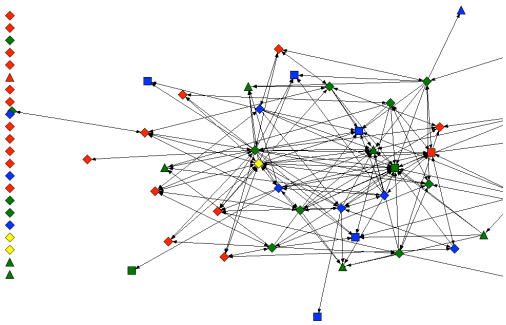
Knowledge network (attribute: expectations)



Communication network (attribute: knowledge)



Knowledge network (attribute: knowledge)



Key: *Diamonds represent Producers; Up triangles represent Suppliers; Squares represent Institutions. [Attributes levels: Green is High level; Blue is Medium level; Yellow is Low level; Red is Very low level.]*

For the sake of clarity we report in Table 12 a summary of the distribution of attributes across the three actors' categories. It can easily be observed that, in general, expectations are lower across producers when compared to institutions and suppliers. However, expectations are also lower in a cross-attributes comparison (i.e. expectations vs. knowledge), a feature which we had already observed following the networks' visual inspection conducted above. As for knowledge, we can notice that almost 50% of producers have medium or high level of knowledge and this percentage goes up to 100% in the case of institutions and suppliers.

Table 12. The Italian bioplastic production networks – attributes distribution

		Expectations	Knowledge
Producers	*Very*	*33*	*21*
	Low	*3*	*4*
	Mediu	*6*	*10*
	High	*6*	*13*
Suppliers	*Very*	*0*	*0*
	Low	*1*	*0*
	Mediu	*7*	*1*
	High	*0*	*7*
Institutions	*Very*	*3*	*0*
	Low	*2*	*0*
	Mediu	*3*	*6*
	High	*0*	*2*

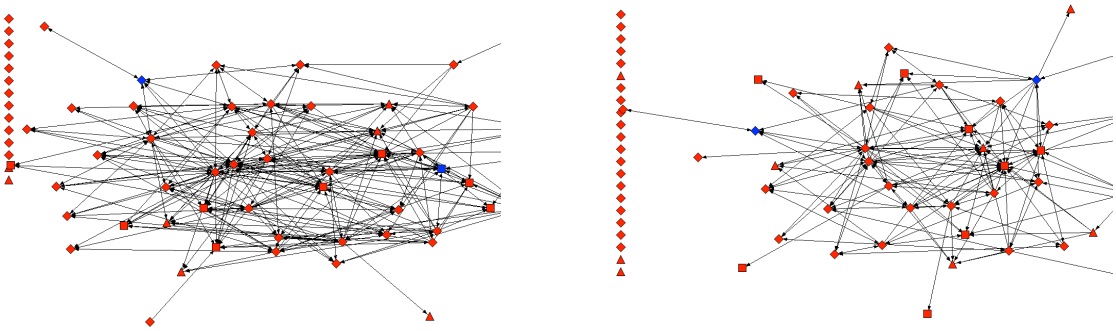
We shall conclude our analysis looking at cut-points present in the above studied networks. In Figure 8 report the communication and the knowledge networks highlighting in blue those nodes which represent cut-points. As discussed in section 3, the importance of cut-points rests in their ability to connect (and, conversely, to disconnect) two or more components of a social network. Hence, these nodes may act as brokers among groups, building bridges between sub-groups which would be otherwise cut-off and split into unconnected components or actors. When considering the flow of any material or immaterial attribute through a social network, a cut-point represents actually a bottleneck through which the attribute must flow to reach a portion of the social network. These nodes are, therefore, quite important in the overall diffusion process, as they directly control a portion of the network which could be

isolated from the rest of the network if the cut-point is unable (or unwilling) to facilitate the flow.

As it looks quite clearly from Figure 8, both communication and knowledge networks are characterised by the presence of only two cut-points, which are also quite peripheral in the overall structure of the two networks. This is indeed a central finding, as it suggests that in the networks in question, which contain only two cut-points, activities of communication and knowledge and expectations exchange among actors are not significantly dependent upon any particular member. The presence of alternative paths of communication among actors suggests that the architectural structure of the two systems is both flexible and unstratified.

Figure 8. The Italian bioplastic production – cut-points analysis

Communication network **Knowledge network**



Legend: *Diamonds represent Producers; Up triangles represent Suppliers; Squares represent Institutions. Cut-points in blue colour.*

5.5 Summing up results and drawing conclusions on the potential niche development

The social network analysis has provided new insight into the network structure of the Italian bioplastics market. By the means of a social network analysis, we were able to identify the key actors forming the Italian bioplastics shopping bags production niche, to investigate the network architecture's properties, as well as to assess the relevance of information bottlenecks.

This network analysis allows us to draw some conclusions on the technological niche potential development. As discussed in section 2, the niche development depends on three key mechanisms that are learning, expectations and networking. As

we argued, these are interlinked as the first two mechanisms rely on the third – i.e. the emergence of a sufficiently interconnected network is a necessary condition for an effective learning process and an upward convergence of expectations. Having this in mind, the social network analysis conducted provided us with the following findings:

1. There is a large and unexploited potential of interactions when comparing who-knows-who and interactions networks with communication and knowledge networks. Yet, also these two latter networks show a sufficiently high level of inclusiveness and average degree.

2. No critical problems are created due to the presence of bottlenecks in the network, which actually seems to be flexible and unstratified.

3. Generally speaking actors are knowledgeable but there is an inefficient use of resources available in the network with a group of knowledgeable actors occupying peripheral positions in the network or being completely disconnected from the central component.

4. On the opposite side of the spectrum, there are sceptical agents (i.e. characterised by low expectations) which have a central position in the communication and knowledge networks.

These findings would suggest that the architectural structure of the network in question offers great opportunities for the technological niche development, some of which are not fully exploited, yet. Actors are overall knowledgeable and can contribute to the learning mechanism letting knowledge flow in a flexible and unstratified network. The weakest feature of the system, which might eventually jeopardise the niche development process, relates to expectations, which are generally low and, more critically, are low for those agents occupying central positions in the scrutinised network. The low level of expectations probably stems from the high level of uncertainty associated with the technology under investigation, a fact which had emerged already in previous studies (Morone and Tartiu, 2013) and that deserves further attention.

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6. Conclusions

1. Reflecting on the research questions

The research behind this thesis has focused mainly on the analysis of particular forms of sustainable transitions, identifying and highlighting possible environmental strategies and public policies to encourage environmental innovations that enable transitions of socio-technical systems towards more environmentally friendly using existing literature, a game theoretical model and a case study of Italian bio-plastic in order to better understand the basic dynamics of a transition process. Four questions were used to guide this research:

1. What insights are available from existing literature that can provide responses on the debate of the effects of environmental regulation on industries' competitiveness in sustainable transition processes?

2. How theoretical applicable are these responses to the introduction of an environmental standard? Does the case offer additional insights that allow a win-win situation to arise?

3. What insights are available from existing literature on how to promote and govern a transition toward sustainability?

4. How applicable is the SNM approach to the case of the Italian bio-plastics sector? Which is the potential development of the bio-waste technological niche and which are the factors that may hinder the full development of such technological niche?

Question 1 was addressed in the second chapter where we reviewed existing literature on the debate concerning the relationship between environmental regulations and competitiveness, which emerged since the so-called "Porter Hypothesis" and challenged the traditional trade-off, proposing a new perspective arguing that improved environmental performances, as induced also by environmental regulations, is a potential source of competitive advantage.

Question 2 was addressed in Chapter 3 that provided an additional reason why a win-win situation may emerge within the context of a quality competition framework. The research question was tackled using a duopoly model of vertical product differentiation in which two firms simultaneously choose to produce either a high (environmentally friendly) quality or low quality variant of the good, before engaging in price competition.

Question 3 was addressed in Chapter 4 where we tried to provide a description of the more important theories and approaches to understand and explain (sustainability) transitions and their related main concepts by reviewing them and providing some critical considerations in order to have an exhaustive idea about the current dimension of sustainability transition studies.

Finally, question 4 was addressed in Chapter 5 where, using social network analysis within a strategic niche management framework, we investigated the potential development of the Italian bio-waste technological niche and the factors that may hinder the full development of such technological niche.

2. Summary of findings

In recent years, a broad discussion on the relationship between environmental regulations and competitiveness has emerged, relying on the dichotomy between the "traditional" trade-off perspective and the "revisionist" view which argues, instead, the possibility that environmental regulations may generate economic benefits that may offset the additional cost of complying with the new regulations (Porter and Van der Linde, 1995). However, authors who supported or criticized both approaches have often analysed the link between environmental policies and economic performance taking into account one or more indicators of a firm's environmental and economic performance, without considering the underlying organizational variables that could affect this relationship (e.g. management, knows how, corporate culture, reputation, etc.). This approach is known as the Resource Based View of the firm (or Managerial Approach) and, taking as fundamental the Porter' s idea, it expands the range of resources that firms can rely on, in transition process toward more sustainable modes of production.

Findings of the main literature show that competitiveness effects of environmental regulations can be investigated by different perspectives and results are influenced by the appropriateness of various measures adopted to address those

effects, additionally, they are highly case-specific and, finally, they depend on the goal and level of the analysis which is carried out. With respect to the level of the analysis, studies may take firm level or consider a sector at country level, with implications on the measures adopted for assessing competitiveness and results obtained. With respect to the goal of the analysis, studies may deal to the first causal link proposed in the Porter Hypothesis, which is the link between environmental regulations and technological change, or they may concentrate on the role played by different environmental policies on innovation and, finally, they may focus on the effects of environmental regulations on competitiveness. Therefore, the available empirical evidence does not reveal that any strand of research has succeeded over the others, as no unique relationship has yet prevailed in the literature or empirical studies.

As emerge in the literature survey proposed in chapter 2, the Porter Hypothesis (PH) developed a large debate in the political arena, especially in the United States, because it contradicts the idea that environmental protection is always detrimental to economic growth. The PH has been invoked to persuade the business community to accept environmental regulations, as it may benefit from them along with other stakeholders. In short, well-designed environmental regulations might lead to a Pareto improvement or a "win–win" situation in some cases, by not only protecting the environment, but also enhancing profits and competitiveness through the improvement of the products or their production process or through the enhancement of product quality. Recently, some authors reported some mechanisms through which a Porter result may emerge. These explanations have in common the existence of some kind of market failure that provide a ground for environmental regulation to benefit firms; though this failure may occur at different levels, corresponding to different interpretations of the Porter hypothesis. In this thesis we report an additional reason why a win-win situation may emerge in a context of vertical product differentiation. The economic rationale behind our findings is the following: firms sometimes must decide whether to stick to a product with a low environmental quality or jump, through a transition process, to produce a high environmental quality product. High quality products typically entail higher production costs, although consumers reward this effort to some extent by being willing to pay a higher price for a cleaner product (see, for instance, Wasik, 1996). In this framework, a firm could be reluctant to shift to produce high quality goods

as this may put her at a disadvantage when competing in prices. The reason is that low quality providers could benefit by offering cheaper products, serving a large fraction of demand and, thus, making the introduction of environmentally friendly products in the market not profitable. Nevertheless, if all firms shifted to produce high quality products, they could jointly benefit from the higher willingness to pay of consumers without incurring the risk of being overtaken by their competitors. In game theory this situation corresponds to a prisoner's dilemma in which the Nash equilibrium of the game is Pareto dominated by a different strategy profile that, however, is not an equilibrium because all the agents would have individual incentives to deviate from it. In our framework, environmental regulation can provide a win-win situation by inducing all firms to shift to environmentally friendly products and make both the environment and firms better off. We derive our results within a model of vertical product differentiation where two firms have to simultaneously choose the environmental quality of the good they produce (which can be either high or low) and, afterwards, engage in price competition. The model is a standard model of vertical product differentiation, in the line of the seminal papers by Gabszewick and Thise (1979) except for the fact that we restrict environmental quality to be discrete - rather than a continuous variable - so firms can only choose between a finite number of options to produce their good. This could be a rather natural and realistic modelling strategy in many contexts, since firms usually make discrete decisions related to the environmental quality of their products: using regular plastic or bio-plastic derived from waste, using fossil fuels or renewable energy, etc. In this framework, we showed that it is possible to find environmental policies (environmental standard) that may simultaneously improve environmental quality and increase the profit of firms. This instrument is able to determine a shifting toward a new profit-enhancing configuration by solving a coordination failure and, at the same time, it is able to promote a transition toward more sustainable modes of production and consumption processes, providing a theoretical basis for the Porter hypothesis to succeed.

Moreover, a quite recent strand of literature has begun to be interested in exploring the issues of how to promote and govern a transition toward sustainability, i.e., a fundamental transformation towards more sustainable modes of production and consumption, because they play an important role in the nexus of economic development and a sustainable energy system transformation and because

environmental regulation, oftentimes, is taken into account by policy makers in order to promote such changes. Sustainability oriented innovations and technology studies have received increasing attention both in the policy arena and in social-science research. In theoretical terms, four frameworks so far have achieved a prominent position in transition studies. These include transition management, strategic niche management, the multi-level perspective on sociotechnical transitions and technological innovation systems. Strategic Niche Management (SNM) is an analytical technique designed to facilitate the introduction and diffusion of radically new sustainable technologies through societal experiments. According to SNM, intensive networking among social actors is a crucial process for the successful incubation of new technologies. However, the manner in which innovation success relates to different characteristics pertaining to the structure and functioning of these actor networks has remained rather unclear. Against this background, in the second part of the thesis, we concentrated on the bio-waste technological niche development and on its role in the sustainability transition towards a bio-based economy (i.e. an economy which makes the most out of biomasses in terms of energy and production of other by-products). In particular, by the means of a social network analysis, we were able to identify the key actors forming the Italian bio-plastics shopping bags production niche, to investigate the network architecture's properties, as well as to assess the relevance of information bottlenecks. Having in mind that the niche development depends on three key mechanisms, which are learning, expectations and networking, the network analysis allowed us to derive some conclusions on the potential development of the technological niche under investigation. Namely, the architectural structure of the network in question offers great opportunities for the technological niche development, some of which are not fully exploited, yet. Actors are overall knowledgeable and can contribute to the learning mechanism letting knowledge flow in a flexible and unstratified network. The weakest feature of the system, which might eventually compromise the niche development process, relates to expectations, which are generally low and, more critically, are low for those agents occupying central positions in the scrutinised network. The low level of expectations probably stems from the high level of uncertainty associated with the technology under investigation, a fact which had emerged already in previous studies (Morone and Tartiu, 2013) and that deserves further attention.

3. Future research directions

Throughout this thesis we have identified avenues for future research. As a final step, this section collects them together.

The first research direction is to actually test if a win-win situation might be achieved by involving further forms of environmental regulation in which social welfare as well as the private net benefits of firm adhering to such regulation can be increased. Thus far, we have assumed that the government will use a simple instrument (an environmental standard) to persuade firms to adopt the environmentally friendly product. It could be interesting to consider whether the possibility of obtaining a win-win result is robust to the use of an even more realistic policy instrument, such as an effluent tax which imposes on those producers of standard (low environmental quality) goods a tax $t > 0$ per unit produced. Moreover, we have assumed that the only differentiating factor between the variants of a given good is that associated with environmental quality and that, therefore, when both firms choose to produce goods of the same environmental technology consumers are totally indifferent between purchasing products from one or the other firm. It might be interesting to consider a model of vertical and horizontal product differentiation and explore the impact of other differentiating details (brand names, locations, etc.) that make goods of equal environmental quality into imperfect substitutes of each other.

A second research direction is to expand the applicability of the SNM approach used in this thesis to other technologies, in particular those in domains where there are many possible niches, on end-user and producer-as-user technologies, and those at an earlier innovation phase such as prototype testing. Moreover, within the multilevel framework, a better understanding of the sources of pressure (acting at the landscape level) on the incumbent socio-technical regime - this could be done identifying the key stakeholders involved in the transition process as well as the channels through which they exert pressure - would complement the findings in this thesis and produce a set of insights that might be more widely applicable.