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The co-evolution of sectoral regulation and technological innovation: the case of detergents industry in Europe

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The co-evolution of sectoral regulation and technological innovation: the case of detergents industry in Europe

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Abstract

This paper contributes to research addressing interrelationships between technological and policy changes by exploring the co-evolution of sectoral regulation and technological innovation in the detergents industry in Europe. We view as regulation an endogenously created institution that evolves over time and in alignment with other socioeconomic factors, among which we focus on technological change. We argue that the innovation and regulation processes are evolutionary processes that interact overtime and their co-evolution is facilitated by knowledgeable and purposeful agents who wish to influence their institutional environment. Given our empirical context we find that the opportunity provided to private actors to participate in the policy process, share information and collaborate, contributes to the improvement of their knowledge. In turn, improved knowledge increases the innovative potential of actors while it builds their bargaining power and increases the possibilities private actors have to influence their institutional environment. Favorable institutional conditions have been recognized as a factor conductive to innovation and in this sense, we can witness a circular and interactive relationship between the regulatory and innovation process.

Keywords: regulation, technological innovation, private-public interactions

1. Introduction

The notion that institutions and policies always matter in all processes of technological learning and economic coordination and change, is supported by sound theoretical arguments (Cimoli et al., 2006), yet "the interrelationships between changes in governance and changes in technology have been either largely overlooked or found somewhat intractable" (von Tunzelmann, 2003:336). This paper contributes to such research demand by exploring the co-evolution of sectoral regulation and technological innovation in the detergents industry in Europe.

As with most notions in social sciences, there are several definitions for regulation, which reflect different research concerns and research agendas (Jordana and Levi-Faur, 2004). Most frequently regulation is defined as a restrictive public action that aims to constrain private activity in order to promote the public interest (Francis, 1993) or more generally as a set of rules with controlling purpose (Majone, 1996). In this vein, Selzinch (1985, cited in Majone 1996:1) defines regulation as "sustained and focused control exercised by a public agency over activities that are generally regarded as desirable to society". Adopting a more elaborate approach regulation can be viewed as any set of rules and behaviors that make possibly conflicting decentralized decisions compatible. In this paper we embrace and expand such a view and consider regulation as an enabling institution that goes beyond disciplining and controlling agents' activities and is able to contribute to the transformation of economic and non-economic social relations, facilitate economic coordination (Jessop, 1995) and reduce uncertainty (Peet, 2007).

With regards to its policy rationale, and following the public choice theory and its variations, regulation has been viewed as a virtually costless policy instrument supplied in response to public demands for the correction of inefficient or inequitable market practices such as externalities, monopolistic phenomena, information failures, and inadequate provision of public goods (Posner, 1974; Hix, 1995; Majone, 1996). Tackling market inefficiencies has provided a sound justification for public intervention in the form of regulation, a rationale that dominated EU decision making at least till the 1960s (Majone, 1996) along with a view of regulation an enemy of competition - "regulation and competition are rhetorical friends and deadly enemies" (Stigler, 1975: 183)-. In his economic theory of regulation, Stigler (1971) argues that the primary function of regulation is the redistribution of income rather than the correction of market failures, a view that has been liked with regulatory capture theory that perceives regulation as supplied by governments in accordance and response to the demands of interest groups struggling among themselves to maximize the incomes of their members (Bernstein, 1955; Ziegler, 1964; Posner, 1974).

With regards to technical change, regulation has been commonly viewed as an externally imposed impediment of innovation that induces research efforts of reactive nature (e.g. Steward and Wibberley, 1980; Ashford and Heaton, 1983). We find that theories focusing on the corrective function of regulation and implying a reactive nature of research efforts to an externally imposed impediment of innovation that aims to resolve undesired market phenomena have a limited explanatory power when called to explain the observed

interrelationships between governmental and technical change. On the contrary, we are in agreement with Irwin and Vergragt (1989) who argue that regulation cannot not only be considered as a post-innovation check on undesired effects of technological change, rather should be viewed as a tool for directing research efforts towards socially desirable ends. Hence, apart from tackling non-successful past policies, regulation becomes also a means of facilitating future policy targets (like for instance the Single Market in the EU, sustainability, competitiveness) and it is formed on the basis of interactions of knowledgeable agents representing both the private and public sector. Adopting this approach to the nature and role of regulation, this paper contributes to the comprehension of the continuous interaction between governmental action and technological change as this is depicted by the interaction of sectoral regulation and technological innovations in the detergents industry in Europe.

This industry has a long presence that allows for a historical account of the co-evolution of regulation and innovation and exhibits an interesting and continuous innovative activity, as its current form is the result of a major technological transition from soap to synthetic detergents. Innovation has always been an essential element for firms to survive the fierce competition characterizing this traditionally concentrated industry, while the nature of its product, particularly detergents for domestic use, is one that steadily attracts regulators' attention and increases demand for public awareness and intervention until today.

Considering the long time period we aim to cover (i.e. from the 1930s onwards) different sources of evidence are employed. Empirical evidence for the evolution of the industry and its legislative plexus till the 1990s is drawn mainly from secondary data (i.e. existing studies for the industry and its regulation, documentation and online resources). Evidence from the 1990s onwards, when the regulatory activity is intensified, are the combined output of secondary sources and 27 semi-structured interviews with various types of stakeholders (private companies (large and small), industrial associations (national and European), policy makers (national and European) and NGOs (national and European branches)). Aiming to capture the interactions between public and private agents we use three mini cases of the most recently promulgated regulations affecting the detergents industry.

The remainder of this paper is organized as follows: Section Two provides the theoretical stance this paper adopts with regards to the relationship between regulation and innovation; Sections Three to Five construct the conceptual framework for analyzing the co-evolution between the regulatory and the innovation process; Section Six sets the empirical context of our study; Sections Seven and Eight provide the empirical evidence supporting our arguments and Section Nine concludes.

2. Establishing the relationship between regulation and innovation

Existing research has been very insightful in establishing and grounding the relationship between regulation and innovation and provides evidence on the implications of regulation for innovation. General evidence on the importance of regulation are provided

by Palmberg (2004) who notes that in many industrial sectors firms need to master the regulatory set-up in order to commercialize new ideas and Gouldson and Murphy (1998) who suggest that regulation may contribute to the solution of environmental issues by assisting companies to overcome short-term barriers to innovation that commonly prevent them from considering clean technologies. Additional evidence comes from the area of environmental studies that place their focus on the implications of regulation for the development of environmental friendly technologies, while empirical policy studies also confirm the importance of regulation for research efforts. For instance, the analyses of the Finnish results from the (CIS3) show that almost half of the projects that led to successful innovation were triggered by public procurement or regulation (Edler and Georgiou, 2007).

Research interest on the regulatory implications for regulation commenced earlier than the above mentioned studies. The discussion of the implications of regulation for innovation is a topic that triggered scholarly interest during the late seventies and early eighties. Initial research on the issue tends to treat regulation *as an externally posed constraint on the activity of economic agents* (see for example Steward and Wibberley,1980) who are in turn viewed as behaving reactively and ex post to public action (Ashford and Heaton, 1983; Blind, 2004; Jaffe and Stavins 1995; Kemp et al. 2000). Early research faced the difficulty of separating between regulatory and non-regulatory factors impinging upon innovation while it ignored the larger social and organizational changes that regulation brings along (Irwin and Vergragt, 1989). The division between regulatory effects on "main business innovations" and effects on "compliance innovation" proposed by Ashford and Heaton (1983: 127)[1] can be considered as a development towards understanding the non-quantifiable effects of regulation for firms´ operations, as they identify changes that take place in the decision making structure of the firms as well as changes in the technology output. Still, following this reasoning, regulations are considered as part of a wider socio-political context whose role is to reflect the desires of society while technical change is not a goal *per se* rather the principle means to meet regulatory targets. This analysis is confined to changes taking place internally to the firm and the applicability of the Ashford-Heaton framework can be challenged on two grounds; the first is well targeted by Kemp *et al.* (2000) and relates to the fact that the concept of compliance innovation cannot be distinguished from main business innovation in the case of a company that specializes in the production of compliance products. The second issue relates, in our view, to the fact that compliance innovation tends to become an integral part of companies' main business and hence this distinction can only be used to describe the immediate or short term effects of regulation. Further, Ashford and Heaton (1983) argue that the demands that underlie regulation might be inescapable and would prompt some technological change anyway and hence the industry does not participate in the process of formulation in any way, rather, *it is just a respondent to the demands of regulation*. Such an approach contradicts the evidence of this research, which highlights

[1] The former refer to effects on innovative activities that firms had planned to conduct for their own production purposes and the latter relates to innovation required or achieved by their efforts to comply with new regulations.

the active participation of industry representatives in the process of regulation formulation.

The implications of regulation for innovation have also attracted the interest of scholars in the field of environmental studies and have resulted in detailed impact studies of innovation induced by environmental regulation (e.g., Blind, 2004; Klemmer, 1999; Eisner, 2004; Jaffe and Palmer, 1997; Jaffe and Stavins, 1995; Jaffe, Newell, and Stavins, 2003; Rodriguez and Montalvo, 2007). Although these studies provide detailed accounts of technology responses to environmental regulation, they pay less attention to the institutional context within which these technologies are developed and adopted. Further, they say little about the wider implications of regulation for the incentive structure of agents as well as about the strategies deployed by various actors to obtain favorable conditions for their benefit (Kemp *et al.*, 2000). Finally, the emphasis is commonly placed on the effects that regulation has on innovation while much less attention is paid to the impact that technological advancements might have on existing regulatory regimes.

Hence, notwithstanding the value of the approaches discussed so far in establishing and grounding the relationship between regulation and innovation, we find that they sketch a linear view of policy impact on economic processes where public policies are considered as formulated away from economic agents, are then announced and have single-directional effects on economic development (as this is driven by innovation). This is a view we wish to refrain from and in doing so we build upon accounts that argue for an interactive relationship between regulation and innovation that is facilitated by the proactive behavior of purposeful economic and non-economic agents.

Arguments suggesting that technological change and innovation can also trigger regulatory changes (i.e. the reverse direction of the relationship between the two processes) can be built upon examples of such as the advancements in medicine that have stimulated regulatory action to ensure human safety and avoid monopolistic prices; pollution related to industrial production that has been the source for many environmental regulations and so forth. Towards this end and discussing the increase and change of character of legal texts, Eads (1980) points out that technological development is at least partly responsible for the environmental, health and safety standards to which the bulk of the “new regulation” (post 1960s) is addressed. In this vein, Eckardt (2004) analyses how negative technological externalities induce legal action i.e. induce the refinement or substitution of existing legal provisions, as old regulations may become obsolete in the presence of a new technology (Lengrand *et al.*, 2002).

Certainly, and in a positive sense, technological change might facilitate and expand regulation. For instance, information and communication technologies have proved to be vital for the implementation of any type of regulation, while regulation might be expanded due to new processes as Wilson (1980) describes when analyzing the case of process innovation introduced in the electricity industry. These contributions point to Sahal’s (1985: 62) conclusions on the relationship between technology and its environment that “neither of the two is a sole determinant of the other” and that “technology is both an object and an instrument of socioeconomic evolution”. Indeed, in

their study of the pharmaceutical industry during the 1990s, Abraham and Reeds (2002) suggest that the relationship between regulation and innovation may not always be unidirectional, an argument reinforced by (Maatta, 2001) who finds that regulation affects innovation and in turn the outcomes of technological change create new conditions to be regulated. In this vein, the notion of co-evolution between technology and different types of institutions (Nelson, 1994, 1995; Lundvall, 1988; Rip and Kemp, 1998; Andersen and Walsh, 2000; von Tunzelmann, 2003; Sotutaura and Srivinas, 2006; Carlsson and Stankiewicz, 1991; Leydesdorff and Etzkowitz, 1996)[2] becomes very relevant and is a concept that guides our study of the relationship between the regulatory and the innovation process. Aiming to follow the manner in which these two processes evolve overtime we adopt Nelson´s (1994) insights summarized in the following:

> "*Recognition of the role of technical societies in the development of modern technologies opens the door to seeing a wide range of institutions that may co-evolve with technology. Often legal structures need to change (…) there are almost always issues of regulation (…) In many cases new public sector activities and programs are required (…) All these examples indicate that the evolution of institutions relevant to technology or industry may be a very complex process, involving not only the actions of private firms but also organizations like industry associations, technical societies, universities, courts, government agencies, legislatures, etc. (Nelson, 1994: 56-57)"*

Keeping this as our conceptual guide, we next discuss the attributes of the innovation and regulatory process that devise their interaction.

3. The innovation process and regulation

Innovation studies have approached innovation as a process for which institutions matter and which is embedded in the wider socioeconomic evolution (Nelson, 2000; McKelvey, 1996). In accordance to this premise, Saviotti and Metcalfe (1984) highlight the importance of the "diffusion environment" within which an innovation is placed and its relevance to the accumulation of experience (learning by doing and learning by using) which they view as an essential mechanism for technological change. Specifically to the role of regulation as part of the environment within which innovation is gestated and diffused, and seeking to identify examples of "forces that provide inducements for technical change" Rosenberg (1969:3) cites governmentally imposed regulation as an example of an inducement mechanism or "focusing device" to the direction of technological innovation in order to support his argument that economic incentives, though very important, "cannot explain properly the sequence and timing of innovative activity". In the same vein, Carlsson (2002: 17) remarks that since "the confrontation of technological possibilities and the market takes place in an environment largely determined by actors, networks and institutions" any structural change occurring in this environment can trigger technological change and the regulatory plexus is one of the areas where structural change occurs. Similarly, and introducing the notion of

[2] The list of references mentioned is by no means exhaustive; there are just indicative of the penetration of the term in science, technology and innovation studies.

technological transitions as “major technological transformations in the way societal functions are fulfilled”, Geels (2002: 1257) notes that such transformations involve, not only technological changes, but also, changes in “socio-technical configurations” that include other (non-technological) elements, such as user practices, *regulations and policies*, industrial networks, infrastructure, etc.

The notion that innovation is gestated within and interacts with a wider environment composed of actors, processes and institutions, is also the underlying principle in the systems of innovation literature, which we find relevant to this study mostly in its sectoral and technological expressions. Accordingly, a sectoral system of innovation is described as comprising of products, agents (including non-firm organizations), basic technologies, inputs, demand, and the related links and complementarities (both static and dynamic), knowledge and learning processes, mechanisms of interactions both within firms and outside firms, processes of competition, selection *and institution*s *(such as standards, regulations, labour markets, etc.)* (Malerba, 2002). Although this approach establishes the multi-actor environment within which innovation occurs, it provides less insights for the mechanisms or processes of interaction between the elements of the system, an aspect better captured in the definition of a “technological system of innovation” (TSI). Following Carlsson and Stankiewizc (1991: 94), a TSI is “a network of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and utilize technology”. An additional approach pointing out the variety of elements involved in technical systems and the pivotal role of knowledgeable actors is Hughes’s (1983: 51) large technical systems that, among other elements, are composed of physical artifacts, *legislative artifacts*, organizations, scientific resources, etc.

A common element of the above approaches is that systems (environments), actors and institutions are at the foundations of the innovation process and need to be considered equally when analyzing the evolution of technology. A more synthetic approach, encompassing all three aspects (systems, actors and institutions) is the one “socio-technical systems” Geels (2004: 898) used for analyzing the development, diffusion and use of technology as well as its impacts and societal transformations. In analysing the role of institutions, Geels (2004) highlights their coordination and structuring functions and their potential to explain not only inertia and stability but also dynamic developments, an issue that was first brought forward by North (1990) and Loasby, (1999) who viewed institutions as means of mitigating the issue of incomplete knowledge. Namely, as institutions organize the opportunities of choice, their presence combined with evolution guarantee that knowledge is capable of co-ordination and improvement (Loasby, 1999) and hence there is greater potential for innovative activities. A common question that arises is “what do we mean by institutions?” Considering our interest in regulation we tackle this question by approaching institutions as sets of rules that have implications for actors’ choices. Within this context, a core assumption of this paper is that technological innovation is facilitated and achieved through the interaction of purposeful and knowledgeable actors whose perceptions and choices evolve and are shaped by various institutions constituting the environment within which actors act and innovations occur.

The manner in which agents that share common problems organize and structure their knowledge defines their common approach to problem solving and this idea of shared heuristics is the underlying principle of the notions of “design space” (Stankiewizc, 2000, 2002), “technological paradigm” (Dosi, 1982), “techno-economic paradigm” (Freeman and Perez, 1988), “technological regime” (Nelson and Winter, 1977; Georghiou *et al.*, 1986), “socio-economic regime” (Rip and Kemp, 1998) and “socio-technical regime” (Geels, 2002, 2004), which are enlightening for the exploration of the factors that influence or direct agents’ decisions.

These notions approach the dynamics of technological change as an interaction between evolving sets of rules and have the common premise of an existing array of possibilities among which purposeful agents need to select. Considering Dosi’s technological paradigms, developments within a paradigm lead to the emergence of a pattern for problem solving activities, namely a “technological trajectory” that actually indicates a specific direction for innovation efforts. Accordingly, and using the notion of design space, Stankiewicz (2000: 237) describes the innovation process as the evolution of design spaces, following four distinct patterns or distinct regimes (craft regime, engineering regime, architectural regime and research regime). In this manner, he describes the evolution of the scope and specificity level of shared knowledge; as interactions between actors intensify, knowledge progresses and the design space becomes more “fine-grained”, meaning that traditional technologies gradually employ more complicated scientific principles that arise during the continuous research exercise and this justifies the expansion of design spaces. Further, as design spaces evolve “common languages” are developed that facilitate the transmission of knowledge within and between design spaces, namely within and between groups of actors participating in the innovation process; this can explain increasing “commonalities among previously unrelated design spaces” (ibid, p.245), namely the convergence of design spaces.

Geels (2004) explains the co-ordination and interaction between different social groups whose boundaries are not easily defined by proposing the concept of “socio-technical regimes”. Socio-technical regimes are an amalgam of different rule sets that are shared among different social groups. The elementary principle for his analysis is that different regimes (technological, science, policy, etc.) become aligned given that some sets of rules are common and simultaneously significant for different regimes and among different social groups; for instance the heuristics of engineers are linked to company marketing objectives that take into consideration users’ perceptions that in turn are linked to formal *regulations* which may also pinpoint open of close research avenues for companies and engineers. Continuing our interest in the manner in which the evolution and interaction of these sets of rules contributes to technological change, Burns and Flam (1987) observe that rule systems are maintained and changed through the effects of agents’ dynamic interactions, which shifts our attention to the significant role of agents.

Agents are part of larger groups and are perceived as knowledgeable and purposeful individuals that carry sets of rules (perceptions, beliefs) stemming from their previous (historical) experiences and interactions. Agents’ individual perceptions are fused when they interact with other agents within and across their group and this is how a common

pattern of activity within a wider configuration is generated. This wider configuration provides a fertile ground for interaction and application or alternation of existing rules which have implications for individual perceptions and re-fuel the process described. It is expected that, since we are dealing with a variety purposeful actors, there will be attempts of groups sharing common heuristics and perceptions to alter the wider configuration of rules towards a configuration that benefits and facilitates their interests. Importantly, actors differ in terms of their power, resources and opportunities and hence conflicts and power struggles are to be expected.

Technological evolution is part of the wider cultural evolution and hence technological change can influence the configuration/system within which it is gestated and occurs while at the same time such configuration sets the context within which technological choices (and their rules) are decided and executed. Hence, technological change is explained in terms of development and crystallization of rules that are diffused, maintained for some period and altered again, given the pervasive effects they have for the wider ecology of rules which they are part of. Adopting such a perspective, path dependencies and lock in phenomena become automatically relevant; indeed existing rules are result of a timely continuation of former perceptions and rules, carried by individuals who need incentives or forceful institutions to alter their established preferences. In this sense regulation is incorporated in the factors that induce agents to alter their research orientation and search for alternative avenues.

4. The regulatory process and innovation

Contesting accounts approaching regulation as an externally imposed impediment on innovation, we consider regulations as endogenously emerging institutions that evolve in accordance to other socioeconomic factors, among which we focus on technological change. The regulatory process is a formal policy process whose analysis primarily belongs to the sphere of political science and this is where our quest for existing research on institutional emergence and change commences. Seeking to identify a definition for "public policy" we follow Hogwood and Gunn (1984), who conclude that in order for a policy to be regarded as a "public policy" it "needs to have been generated or at least processed within the framework of governmental procedures, influences and organizations" (Hogwood and Gunn, 1984: 24). Evidently then, any type of public policy is a result of a timely process that is shaped by existing institutions and involves interactions among public as well as private actors; namely it is cumulative in nature and evolves driven by agents´ interactions.

Nelson and Winter (1982) have argued for the cumulative nature of the policy process by suggesting that current changes in the political sphere can be seen as part of a sequence of earlier changes and as setting the scene for future evolutionary developments and that historical circumstances are essential knowledge that the policy maker needs to possess and continuously update in order to increase the possibilities for the successful planning and implementation of future policies. This approach is also underlying the concept of policy feedback that Pierson (1993) grounds in that "policies produce politics" suggesting an iterative and circular relationship between policy outcomes and the policy process.

Politics are viewed here as the continuous and purposeful interactions between economic and non-economic agents that are located in the interface between the regulatory and the innovation process. With regards to the centrality of interactions, Slembeck (1997) argues that the policy process is indeed a process of agents´ mobilization, persuasion and negotiation.

Two important implications arise from these characteristics of the policy process; the first one refers to path dependencies attributed to the cumulative nature of the process and the second involves learning effects that are link to both the cumulativeness and the continuous interactions of agents. Path dependencies are increasingly becoming part of the political science vocabulary when describing the policy process especially aiming to emphasize the notion of self-reinforcing processes (Pierson, 2000). Path dependencies are possible sources of lock-in phenomena which are common in politics due to inherent aspects of the policy process; more specifically, in politics agents rarely achieve important changes acting individually rather collective action is fundamental to policy change. Hence, individuals might be exposed to information that has been selected from other agents than themselves and hence they may be “victims” of agenda-setting effects (Witt, 2003) which in turn result in unintentionally biased policy choices. Further, changes of rules and patterns are mostly dependent on authority rather than exchange and contracts (as in economics) while the existence of rigid institutions orchestrating the policy process make reversals and changes increasingly unattractive (North, 1990). Finally, even if mistakes become apparent, policy change requires long time periods due to the variety of stakeholders with sporadic participation and minor (individual) influence as well as the difficulty of evaluation of policy action in the short term (Pierson, 2000). Yet, the lack of perfect information and the constraints on available knowledge posed on all types of agents (voters, bureaucrats, policy makers, representatives of interest groups) are likely to induce agents to make further efforts to improve their knowledge, alter their choices and induce purposeful action. Then political evolution can be seen as a learning process whereby agents improve their knowledge capacity and are able to influence and change the set of rules surrounding their action. Hence, changes of political perceptions and beliefs can be justified on the grounds that politics are a subtype of social evolutionary process that relies on knowledge accumulation for its evolution (Modelski, 1996).

The above considerations direct us to propose that the policy process is an evolutionary process fueled by knowledge accumulation and transmission that is facilitated by purposeful actors whose perceptions and choices vary and evolve. Such a process resembles the innovation process that is as well described as an accumulation of knowledge-seeking activities, stressing the interest of agents to gain knowledge about their environment and about the opportunities it offers (McKelvey, 1996). Contrary to innovation studies though, the application of evolutionary approaches to the analysis of the policy process is still very limited although it has been suggested that, in comparison to other political science accounts, evolutionary approaches can provide an account of how policy preferences are shaped over time, and place those choices in a dynamic

perspective without undermining the conception of the rational choosing individual (John, 1998).

In agreement with that evolutionary approaches to policy analysis are enlightening in exploring not only the reasons why policies change and the manner in which new policies emerge, but more importantly the manner in which are diffused and retained in a system and influence innovation, this paper considers the regulatory as an evolutionary one. Such an assumption demands this process to be characterized by a variety of actors whose interactions contribute to the accumulation and transmission of knowledge and lead to continuous changes and improvements based on existing conditions. Our expectations are met considering the structure of the political system within which this process takes place as well as the characteristics of the process itself.

4.1 Path dependence, legal paradigms and learning

The concept of institutional path dependencies has been recognized by institutional economists as useful for explaining the long-term persistence of institutions even when they are considered inefficient (North, 1990) and has been used for the analysis of legal change to describe the persistence of differences in legislation between different political systems on the grounds that national political systems persist and resist harmonization (Heine and Kerber, 2002). More specific to the case of the European regulatory process, the element of path dependence is inbuilt due to the strong interrelation and dependence of institutional structures on the existing legislative plexus. Apart from the process, path dependence is also pertinent for the individual pieces of legislation as often legislative change takes the form of legislative succession and the revision of clauses and annexes of existing legal texts. The examples of the 2004 Detergents Legislation and REACH are indicative of this case. As shown in Annex Two and Three, the latest detergents legislation is the outcome of several revisions of the 1973 Directive regulating the biodegradability of surfactants. Similarly the REACH agreement is the descendant of the Dangerous Substances Directive (1967) that was revisited and improved several times to result in the current chemicals policy. These examples highlight that regulations and policies evolve in response to the changing nature of problems and the problem-solving heuristics.

The latter is the underlying notion of a paradigm developed initially by Kuhn (1970) and developed later by Dosi (1982). Applying the notion of technological paradigms to the case of legislation Heine and Kerber (2002:57) interpret legal rules as “socio-technological instruments” that attempt to solve problems of human interaction in societies and develop the concept of “legal paradigms” as structures “embodying an outlook, a definition of the relevant, problems and trade-offs, and a certain pattern of enquiry and heuristics for solving, new emerging problems”. The analogy between technology and legal rules has also been used by Eckardt (2004) who describes new statutory laws as “legal innovations” that are generated within a legal paradigm. For Eckardt (2004) legal paradigms refer both to the cognitive frame within which novel legal problem-solutions are looked for, as well as to the methods used to generate and disseminate legislative innovations. We find that shifts into new legal paradigms may be

attributed to, both, advancements of knowledge as well as arising legislative inefficiencies. Political accountability enhances the incentives of policy entrepreneurs to improve their knowledge and develop new problem-solving heuristics, as in politics losses are not restricted to financial resources but also to the loss of governing power.

The case study material revealed three examples of shifts to new legal paradigms. The first example relates to changes in the existing institutional structure, i.e. the review and reformulation of the European legislative process towards more participatory models and the consequent alteration of decision making processes and instruments for the enforcement of European law. In the early days of European level regulatory activity, decisions were mostly promulgated in the form of Directives and such an approach resulted in the proliferation of versions of legal texts dealing with the same issue in different countries. Consequently administrative difficulties, bureaucratic overload, ambiguity for the addressees of regulatory authorities and opportunities for non-compliance became frequent phenomena. Considering these constraints, the European institutions have consciously shifted their approach to legal intervention towards the promulgation of new legislation through the conversion of existing Directives into Regulations that are directly applicable -namely they create laws which take immediate effect in all the Member States in the same way as a national instrument, without any further action on the part of the national authorities (EUR-Lex, 2008).

A second example relates to changes in the problem-solving heuristics, and more specifically, the manner in which responsibility is allocated between authorities and addressees. REACH is considered by the industry to have "*set a totally new paradigm in the way we look at the problem*" as it reversed the normal process of product regulation. Before REACH, companies were able to market launch a product and were only obliged to provide safety information if public authorities identified a problem related to the product and challenged them. Hence, the responsibility of testing new products against environmental protection and human safety criteria belonged to public authorities and the provision of information was only a case of reaction to public challenges. However this proved to be a very inefficient way of tackling the matter and its failure was attributed to lack of resources (in the authorities' view) and bureaucratic reasons and lack of competence (in industry's view). The new chemicals regulation, REACH, came to substitute the existing legal paradigm and shift the responsibility to the producers of new technology by reversing the onus of proof. Under the new regime companies can use a chemical for commercial use only if they demonstrate in advance that its use is safe. This transition is considered by the industry as a major revolution in the management of chemicals as it prolongs the time required for new products to enter the market, increases the production costs, and creates possibilities that challenges might originate from more stakeholders whose expertise on the issue can sometimes be questioned.

Thirdly, shifts between legal paradigms can be considered in terms of changes in the scope of regulation. In the case of GHS, the globally harmonized requirements for labeling which rose from the regulation, demanded the development of a transnational and intercontinental regulatory process as no single existing national or transnational regulatory process was adequate or sufficiently dominant to support the development

and implementation of such regulation. This resulted in a new legal process based on international collaboration.

These examples indicate transitions to new legal paradigms due to arising inefficiencies and the continuous improvement, accumulation and transmission of knowledge between the increasing variety of stakeholders involved in the regulatory process. Changes in legislation are the combined results of advances located in various scientific disciplines and embodied in individuals belonging to various social groups. In our case, changes have been induced on the one hand by advances in chemistry and consequently the development of new substances as well as the development of testing methods to assess the properties of the new substances. The penetration of such knowledge into the policy circles and especially into the regulatory agencies resulted in responsive efforts on the part of regulators and policy makers to develop processes and instruments appropriate for the mediation of issues related to the assessment of chemicals. On the other hand, political and legal science has also been evolving following its own momentum in response to the changing characteristics of the European political system. Policy objectives based on the rationales of integration and harmonization are translated into efforts for the development of policy processes, institutional structures and policies aiming to facilitate the governance of this multi-actor and multi-level system which, as mentioned above, offers a fertile ground for interaction and information exchange. In support of the latter, Slembeck (1997: 227) notes that the task of politics is to provide a "commonly accepted basis of collective action" and hence, similarly to innovation, the legal process can be seen as a problem solving process whose resolution is determined and dependent upon the mobilization of various types of agents that share knowledge and heuristics and collaborate to achieve their targets.

4.2 The variety-selection-retention triptych

Scholars have identified the three sequential mechanisms that lie at the heart of evolutionary processes and that we expect to find at work in the regulatory process. Loasby (1999: 25) notes that evolution comprises of "the generation of variety, the reduction of variety (selection) and some persistence (retention) both in the characteristics of the variants and in the environment in which they are selected".

The **generation of variety** in evolutionary applications in social sciences is ensured by the fact that agents are capable of experimenting and discovering new rules and, thus, continuing to introduce behavioral novelties into the system (Dosi and Nelson, 1994). In politics variety refers to policy strategies, programs and instruments and is attributed to the diversity of ideas, preferences and interests of policy agents that compete to bring their concerns onto policy agendas (John, 1998; Slembeck, 1997; Modelski, 1996). Regulations can be considered as formal expressions of rules whose variety is guaranteed by the array of policy problems that arise from interactions of agents with different political preferences and beliefs which themselves evolve in response to existing institutions (Rubin, 2002) and introduce new knowledge into the political system. Following Dopfer *et al.* (2004), the introduction of new knowledge carried by an agent with a new understanding and with skills of persuasion into a system of actors is the

initial phase of an evolutionary process generating new rules, an idea which offers us a clear starting point for analyzing the process of emergence of regulations.

Certainly not all newly introduced issues are or can be resolved by regulatory action and hence **selection** must take place to reduce the variety (and number) of issues considered as most vital to attract policy resources. An aspect that distinguishes biological and social sciences models of evolutionary analysis is that in the social sciences both variation and selection processes are largely dependent and controlled by purposeful individuals (Pierson, 2000) or following Loasby (1999), are channeled by human institutions. This implies that selection criteria may evolve in accordance to the forces influencing agents' beliefs, perceptions and preferences and hence, which given the social context of politics selection criteria, may confront the question of "endogeneity" (Dosi and Nelson, 1994: 156).

The third building block of an evolutionary process is the existence of "inertial forces that provide continuity to what survives the winnowing" (Nelson, 1995: 56), namely the existence of a mechanism that facilitates the adaptation and maintenance of novelties introduced in the system. Interpreting novelties as new sets of rules, (Dopfer *et al.*, 2004) refer to this stage as "**retention**" which involves the maintenance of the novel rule and its replication; retention describes a phase in which the new rule is normalized and new divisions of labor emerge including structures of knowledge as well as regional and industrial organization. In our view, the entrance of a new rule at this stage, constitutes a proof of fitness and signals the commencement of a period of relative stability in the sense of the temporary cease of struggle of ideas and interests, related to the particular political problem. In politics the adoption and maintenance of novel rules in the system is ensured, at least for a considerable period of time, due to the characteristics of the institutional structures within which they evolve. Namely, once a regulation reaches the stage of implementation its diffusion and retention in the system is guaranteed by the principle of compulsory compliance and, then, novel regulations can be seen as legal innovations that are the outcome of a collective problem solving process (Eckardt, 2004).

Describing the regulatory process through an evolutionary lens, what we actually witness is a course of knowledge originating from individual ideas and perceptions and its transformation into constitutional rules through collective problem solving activities. Hence, the process of emergence of a new policy –regulation- can be viewed as a process of knowledge accumulation, organization and transmission, resembling the innovation process. Politics offer a forum where a variety of stakeholders interact and purposefully reveal their preferences. Policy targets and demand for well articulated policy instruments encourage efforts for a combination of knowledge distributed among various interest groups; such efforts result in institutional innovations in the sense of novel structures of knowledge with implications for the behavior of all agents that participated in their construction.

From the above, it follows that the processes of innovation and regulation present similarities in the way they are facilitated and evolve over time. Research on the co-evolution of the two processes is still nascent; Eckardt (2004) develops a theoretical

approach to describe the co-evolution of judge-made and statutory law with technology and identifies wealth effects attributed to negative technological externalities as the inducement mechanisms for legal change. In this vein, she suggests that the emergence of statutory innovations is dependent on the action of political entrepreneurs, who do not "react passively to the demand of voters or interest groups, but rather create commonly shared perceptions of the underlying problems and offer statutory innovations" (Eckardt, 2004: 19). This explanation certainly offers reasoning for the cases in which regulation is indeed a result of technological externalities. Nevertheless, its emphasis on the role of policy makers disregards the important contributions and influence exerted by other types of stakeholders on the outcome of the policy process. As for the implications of legal innovations for innovation, Eckardt (2004: 19) constrains the role of the new legislation to determining "who has to bear the costs of negative technological externalities". This view, although important, does not encompass the breadth of implications that regulatory change brings along especially regarding changes in the mindsets of actors. Bearing this in mind, we place actors and institutions at the core of our analysis and argue that the co-evolution of the regulatory and innovation processes innovation is shaped by a variety of intentional and knowledgeable actors able to interact and alter their institutional environment.

5. Actors and institutions devising the co-evolution of the two processes

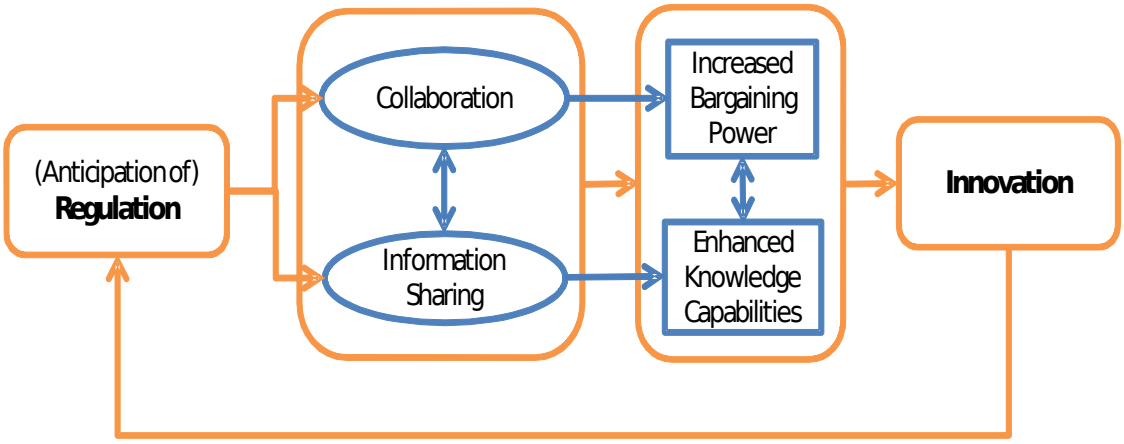
The interaction between agents and institutions is the main premise that determines the nature of technological and political choices and hence shapes the direction of research and policy efforts. Adopting an evolutionary approach to follow the two processes we acknowledge that agents' knowledge is incomplete, and given this constraint it is essential that individuals organize the knowledge they posses and combine it effectively in a way that will assist them to solve their problems. Hence, actors resolve their problems through collaboration, meaning that individual knowledge gradually becomes a population property (Metcalfe and Foster, 2004; Scharpf, 1997) which assists to the formation of more informed decisions.

The importance of information sharing and collaboration for innovation has already attracted scholarly interest and has become the focus of a growing body of literature analyzing the increasing reliance of firms on collaboration to conduct R&D (Gulati, 1995; Powell et al, 1996; Osborn and Hagedoom, 1997). Depret and Hamdouch (2000) emphasize the existence of two opposing forces, increasing competition on one hand and intensified collaborations between competitors on the other, which lead to changes of the rules of the game (i.e. moving from a strict inter-individual level towards more and more "collective" interactions within a play of intra- and inter- coalitions and networks of firms). In addition to factors such as globalization of markets and competition, accelerating pace of technological change and changes on the preferences of consumers (Nonaka and Kenney, 1991; Kivimaki et al. 2000), this trend has also been attributed to regulation as an inducing factor for more frequent and more complex information exchange while setting standards and directing technological efforts (Teece, 1994). Still, the argument addressing regulation as factor contributing to collaboration views regulation as an external force impinging upon innovation; this is an assumption we wish to relax given

the changing nature of the government-industry relationship that is manifested specifically in the case of European policy making.

As described in the following section, the institutional structure facilitating European politics and the demands for information exchange it entails allows and guarantees that frequent and purposeful interactions take place and induce collaboration between private and public agents. The opportunity provided to private actors to participate in the process, share information and collaborate, contributes to the improvement of their knowledge. In turn, improved knowledge increases the innovative potential of actors while it builds their bargaining power and increases the possibilities private actors have to influence their institutional environment. Favorable institutional conditions have been recognized as a factor conductive to innovation and in this sense, we can witness a circular and interactive relationship between the regulatory and innovation process; namely, the anticipation of regulation triggers firms' interest to influence their institutional environment while they become more knowledgeable and capable of conducting innovation and altering their institutional surroundings. The following figure depicts this interaction:

Figure 1: Interactions between regulation and innovation



6. Empirical Context

This paper is empirically contextualized in the European political system, the detergents industry and specific regulations formulated at European level.

The European political system is an institutional structure that is characterized by its non-hierarchical institutional design (implying different levels and arenas are characterized by a high degree of institutional and functional interdependence due to intense institutional interlocking between supranational and national institutions), the non-majoritarian mode of decision making (which places negotiations among the relevant actors at the core of the decision making process) and the dynamic relationship between various decision-making levels (Grande, 2001).

The respective consequences from this list of characteristics are summarized in a high demand for policy coordination and a partial redistribution of power between the organizations involved; these characteristics create advantages for those actors who act at the interfaces between levels and arenas of decision making and significantly increasing the number of strategic options for the actors involved. Placing actors and their interactions at the core of the decision making process, the European system of multi-level governance has produced a distinctive type of interest representation with a high number of points of access and increased possibilities of private agents to influence public policy making.

Within this fragmented and continuously transforming system (Coen, 1997; Knill, 2001) the regulatory process is a dynamic institutional structure that evolves to meet challenges posed by developments such as globalization, technological change and crisis situations. Nowadays, EU regulations are an outcome of the co-decision process[3] that was introduced in 1992 after the Maastricht Treaty, built on the rationale of enhancing transparency and increasing participation (Crombez, 1997). The co-decision process increased the steps of the legislative process, increased the density and frequency of interactions, and created new access channels to various interest representation groups (i.e. NGOs, industrial associations or individual firms). This institutional change provides a further and more formal guarantee that a variety of interests are actively represented in the regulatory process and is accompanied by a redistribution of institutional responsibilities and influencing power. The large scope and number of issues to be solved through this process combined with the understaffing of the public apparatus (Bouwen, 2001) has been increasing the demand for expert knowledge available by non-governmental actors. Within this setting, agents that possess the most relevant and reliable information are the ones granted access to the regulatory process and the ones most likely to influence its outcome. Given the stage and timely character of the regulatory process from its initiation to its implementation, the evaluation of the quality of information provided by private agents takes place at various stages via formal consultations and expert group meetings, or informal communication among the participants, and thus increases the demand and forms of collaboration. Broscheid and Coen (2003), suggest that the institutional structure of the European political system has inbuilt incentive and sanction mechanisms with regards to the transmission of valuable and false information; incentive mechanisms can take the form of privileged access to information about policy intentions, grants and favorable term contracts, while sanctions mechanisms to restrict opportunistic behavior are usually imposed by future exclusion from the negotiations.

In addition to the intensity of participation of different types of actors in the European policy process, what has also changed is the locus of decision making. Especially with regards to regulatory policy the locus of political activity has gradually been transferred from the national and towards the European institutions and as a consequence the modes of interest representation have moved as well towards European political channels (Coen,

[3] See Annex One for the detailed steps of the process

1997). This shift towards Brussels is a combined result of the structure and characteristics of the European political system presented above and the ongoing efforts for economic integration.

Within this policy context, the active and significant role of private firms (among other actors) in the policy process is highlighted in the literature. The Single European Act (SEA) signed in 1987 is considered to be a milestone for the shift of strategies of firms with regards to their interest representation. Coen (1997) describes the patterns of interest representation before and after SEA and points out the lobbying boom documented in the late 80s early 90s. From the 90s onwards firms have evolved into "a sophisticated policy actor capable of establishing alliances with countervailing interest and fostering direct links with the Commission" while "EU institutions become political entrepreneurs and seek to encourage greater stakeholder participation" (Coen, 2007). The evolving and central role of private firms in the European policy process has attracted the attention of scholars who try to identify the theoretical foundations of the growing participation of firms in the policy process (Coen, 1997; Salisbury 1984; Ronit and Scheider, 1999; Boscheid and Coen, 2003, 2007; Majone, 1996; Eising, 2007; Woll, 2006; Shaffer, 1995). Of particular interest for this paper is Bouwen's (2001) supply and demand approach used to explain the degree of access of interest groups in the EU according to the type of information exchanged. What is very relevant to our study is Bouwen's finding that places (large) private firms at the centre of the EU regulatory process. According to this approach when the EU and particularly the EC decides to (based on the right of initiative for regulatory reform) introduce new or modify existing regulation, there is a high demand (on the side of the EC) for expert technical knowledge that is usually located within the private firms . Firms have an incentive to offer this kind of knowledge in return of gaining access to the negotiations linked to the regulatory change. Firms with the most credible and up-to date information are in a more favorable position and hence technologically developed and knowledge intensive firms become protagonists in the process. Hence this type of firms may enjoy competitive advantages not only due to their technological capabilities and innovative potential but also due to the higher possibilities they have to gain access and influence forthcoming legislation; achieving the latter will only reinforce the former as favorable regulatory conditions are meant to provide incentives for innovative efforts._

The non-governmental protagonists of the regulatory process in our case represent the detergents sector. This industry dates back to the first half of the century and the extended use of its products has induced regulatory activity since the sixties. The strong link of the industry with the general public and the early exposure of its representatives to governmental controls in the form of regulations justify why the industry is a fertile case for analyzing the mode of participation of private agents in the regulatory process and observing the changing boundaries between market and non-market organization. The domestic use of the industry´s product and its incorporation in the chemicals industry, has guaranteed the continuous interest of public authorities in the activity of the industry, and hence public intervention remains a relevant issue until today, offering a more than forty years period for inquiry. Aiming to capture the interactions between

public and private agents we use three mini cases of the most recently promulgated regulations affecting the detergents industry i.e. the 2004 Detergents Regulation, the new chemicals regulation dealing with the Registration, Evaluation, Authorization and Restriction of Chemical substances (REACH) and the Globally Harmonized System for Classification and Labeling (GHS) (see Annexes Two, Three and Four respectively).

Seeking to establish an initial link between regulation and innovation we found that traditional indicators could not offer information on the factors that induced innovation and hence could not attach innovations to regulation. For instance, the amounts spent by firms to tackle regulatory challenges cannot be easily estimated firstly due to the aggregated nature of firms' accounts and secondly due to the fact that the exact time when firms start spending for compliance cannot be precisely pinpointed, as firms tend to react proactively driven by anticipation. Further, patent measures do not provide information about the inducement mechanisms of innovation and hence causality cannot be implied. In addition, patents do not always describe the applications of a new substance which can be problematic in our case. More specifically, the properties of detergents depend on the combination of ingredients that, isolated, may exhibit different properties than when combined, while the possible combinations are numerous. Moreover, not all new products are patented as compliance might only be a matter of recombining existing substances. Taking these issues into account, trade journals were used to extract data including announcements of new products that were linked to regulatory requirements and firms' participation in programs and collaborations related to compliance. Our main source of evidence for this task was the trade journal titled "Focus on Surfactants" that, following our interviewees' advice and desk research, is the most encompassing (and most frequently cited) with regards to the operations, views and trends of the industry. More specifically, we reviewed all issues of the journal from 2002[4] to 2008 and collected all announcements that involved technological and organizational innovations linked to the promulgation or announcement of forthcoming regulations affecting the sector. Next, we counted the announcements per year and compared total announcements before and after 2004. 2004 was the year of the official promulgation of the first of the sectoral regulations under study and was used as a reference point in time to observe trends in respective publications.

7. Co-evolution of sectoral regulation and technological innovation in the detergents industry

7.1 Industry characteristics

Although it is not easy to pinpoint exactly when the detergents industry as such came into being (Davidsohn and Milwidsky, 1967), it is commonly held that the detergents industry is the descendant of the existing soap industry as soap and, later, synthetic detergents are products facilitating the same function i.e. washing. Despite the fact that the main function and use of detergents has remained in principle the same, the

[4] January 2002 was the earliest issue allowing access to the researcher while issues after 2008 are now under review.

evolution of the technical characteristics of the product as well as the improvement of the processes of their production have altered the position and structure of the industry. The detergents industry is now nested in the chemicals industry and is certainly influenced by the characteristics and forces impinging on the operation of the latter[5].

The early involvement of petroleum, oil and organic chemical companies in the manufacturing of synthetic detergents due to the suitability of new varieties of raw material was translated into changes in the structure of the existing soap industry and manifested in the enlargement of the competitive landscape. Especially for the UK, Corlett (1958:122) reports that "the production of the active material was split between chemical or oil firms and the makers of the complete detergent powders"... "the former produce the alkylate while the latter perform the remaining operations of sulphonating, neutralizing, adding builders, spray-drying and packing ". With regards to changes in the competitive landscape and in his annual speech to the shareholders of Unilever in 1953, Lord Heyworth (quoted in Edwards, 1962:216) noted that "a new competitive element has been introduced into the detergent industry. If the soap manufacturer loses efficiency, the chemical manufacturer can and will step into the breach and vice versa".

Taking into account the changing structure of the detergents industry and the division of workings between oil, chemical companies and former soap manufacturers, it is interesting to note that the industry became concentrated from the early days of its development while most of the main players of the current industry had been established since the beginning of the century. Accordingly, and describing the UK market in the fifties and sixties, Edwards (1962: 126) writes: "In its present form [the industry] is a good example of the so called modern oligopoly; but the emergence of this form of industrial organization in the industry dates back to the nineteen-thirties...the scale of production of the principal firms was typically much larger than one has been accustomed to think and by the 1880s nearly all the well known names in the industry have been established". Corlett (1958: 159) notes that the same tendency of large firms to share an increasing proportion of the total soap trade was in evidence in the USA, where "the share of large companies had risen from 66% in 1925 to 80% in 1937"; similarly, in Britain during the 1950s, the market of synthetic detergents was dominated by Unilever and Thomas Hedley (P&G's daughter company) that jointly controlled 85% of the total household detergents market, while by the mid 1960s their combined proportion of the market was virtually 90%, split equally between them (Edwards, 1962).

Currently and on a global scale the competitive landscape does not show significant differences as almost 65% of the global market is divided between large multinational companies producing brand products Euromonitor, 2005; Mintel, 2007) despite the dominance of SMEs in terms of population (aprox. 65%) of the industry (AISE, 2007). The

[5] Accordingly, the chemicals industry is amongst the three largest manufacturing industries in Europe and one of the most heavily regulated (Albach et.al, 1996; CEFIC, 2008) and is characterized by a high level of heterogeneity of sectors and products, a high degree of vertical integration, strong linkages between industries (e.g. textiles, automotive) and a long scientific tradition marked with important innovations (Cesaroni et al., 2001; Albach et al., 1996).

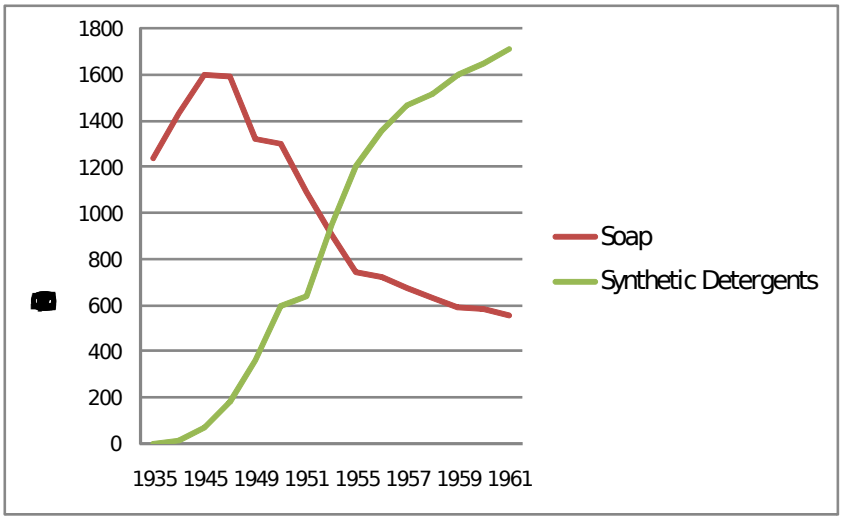
persistence of concentration can be partly justified on the grounds that established firms possessed the capacity to take almost all major inventions out of the laboratories of inventor companies and develop and commercialize them for their own benefit. It seems that in the case of the detergents industry, apart from the apparent improvements of the final product, the implications of technological innovation are mostly depicted in the composition of the industry, namely the types of sectors involved in the manufacturing of the final product, rather than the market structure in terms of market share allocation.

7.2 Product characteristics and their dynamics for development

A detergent is simply defined as "anything that cleans, covering a wide variety of substances used for removing dirt in different situations" (Corlett, 1958:13). Detergents are mainly defined on the basis of the process they facilitate and hence "a detergent may be defined as any agent that facilitates the washing process" (Edwards, 1962: 200). These definitions convey two interesting issues; the first refers to the retention of the main function and the service characteristics of the product over time that implies a concentration of scientific efforts on the improvement of technical and process characteristics. The second issue relates to the possible variety of substances and consequently their combinations that may be involved in the washing process. Indeed, a great variety of detergents compounds have been developed from the thirties onwards based on combinations of different components (i.e. surfactants, builders, bleaching agents, enzymes and other additives). The multi-substance composition of detergents implies that the transition from soap to synthetic detergents was achieved by a combination of individual inventions and innovations regarding each of the components (i.e. surfactants improved, enzymes advanced and so forth).

The continuous improvements in the performance of synthetic detergents vis-a-vis soap and the concurrent incentives for their production related to the increased prices of fats and oils, resulted in the gradual substitution of soap by synthetic detergents during the 1950s (see Figure 2) almost two decades after their invention. The delayed development of their market, especially the one for detergents for domestic use, has been attributed to the initially higher price of synthetic detergents in comparison to soap and their inferior quality and performance especially for cotton fabrics. The latter disadvantage was translated into complaints against the poor performance of the new product which resulted in policy action. In 1943 the Soap Substitutes Labelling and Price Order promulgated in the UK made it an offence to sell a soap substitute unless a licence was given to the formula by the Ministry of Food. This resulted in the mushrooming of small firms producing non-packaged washing products that acquired the respective licences from the Ministry. Edwards (1962:211) reports that in the UK "in 1946 there were over 500 of them and up until 1949 more than 2000 licences had been issued".

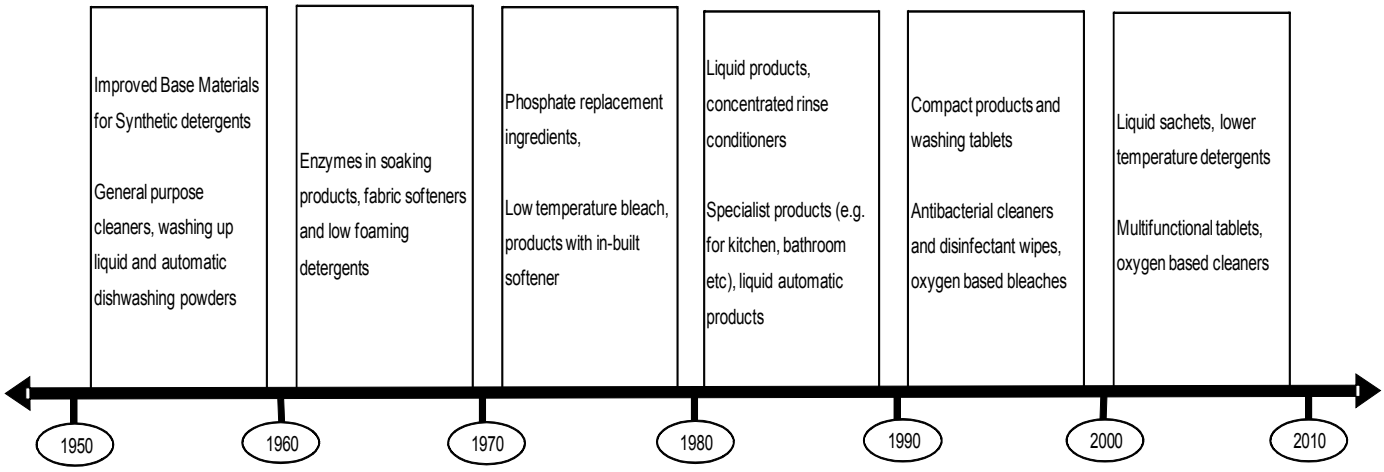
Figure 2: Transition from soap to synthetic detergents



Source: Colrett, 1958:41; Davidsohn and Milwidsky, 1967:3

7.3 From the 1950s onwards

From the fifties onwards the main properties of the new products as well as the base materials had largely been developed and the initial technological and economic incentives had been mostly fulfilled. Nevertheless, technological advances continued further, induced by additional socioeconomic parameters as well as regulatory and technological forces. The following timeline is a useful guide to the main innovations occurring the last five decades:



In the fifties and driven predominately by brand competition, research efforts concentrated on the further improvement of the base material for synthetic detergents combined with attempts to differentiate the product in terms of its form (e.g. from powder to liquid detergents) and use (e.g. surface cleaning and dishwashing). An important advancement in terms of the composition of synthetic detergents occurred in the second half of the sixties with the incorporation of enzymes in the detergent formulation. The beneficial properties of enzymes for detergency had been known in

Germany since the beginning of the century (Gupta et al., 2002; Davidsohn and Milwidsky, 1967), however the first detergent with enzymes in its composition was introduced in Switzerland in 1956 with the name Bio-40, while it was not before 1963 that enzymes were effectively incorporated in detergent powders. Since then and especially during the last two decades, research efforts for the improvement of the performance of enzymes have been intensified and supported by the improvement in genetic engineering techniques[6] and new types of enzymes have been developed and incorporated in the laundry and dishwashing detergent formulations (Kirk *et al.*, 2002; Chen and Wang, 2008).

The sixties and seventies is when public action becomes actively part of the inducement mechanisms for research efforts in the industry, as the extensive use of detergents resulted in public concerns related to the properties of substances involved in the manufacture of detergents. Three distinct examples illustrate such interaction.

Firstly, in the early sixties an increasing amount of foam in the rivers and water drawn from wells was observed (Davidsohn and Milwidsky, 1967: 5). Such phenomena were attributed to the fact that alkyl aryl surfactants, (especially alkyl benzene suplhonates made from propylene coupled to benzene (PT)), resisted biological degradation by bacteria naturally present in effluents. Public action was promulgated in the form of legislations and “gentleman’s agreements”, in the US, Germany and the United Kingdom during the mid sixties. Research prompted by these developments found that the linear alkyl benzene sulphonate (LAS) did not exhibit the undesirable foaming effects and since 1965, when it was first introduced in the US market, this surfactant has remained the primary ingredient for detergent formulations. In addition, it is reported that during the mid 1970’s the low foaming detergents had acquired over two fifths of the total market (Mintel, 2006). Despite the invention and commercialisation of an effective substitute to PT, the issue of biodegradation remains one that still attracts the public eye (as evidenced in Annex Two by the sequences of legislation regulating the issue) while biodegradability has evolved into one of the major criteria for compound development in scientific laboratories.

The second, concern attributed to advancements in the detergents industry was the issue of euthrophication attributed to the use of tripolyphosphates by the detergents industry which evolved into one of the most important users of phosphorus (Corlett, 1958: 141, 143). Almost forty years after their incorporation in the synthetic detergents formulation, the replacement of tripolyphosphates became a hot topic of discussion during the seventies and in the light of environmental concerns, public pressure and the expectation of European legislation, companies launched research programmes to search for substitutes. Henkel was a pioneer in this field and already in 1966 the company initiated its research for the development of substitutes for phosphates which resulted in the 1973

[6] Until the mid 1980 the access to new microbial enzymes was largely depended on to the availability of new source organisms which could be used in a production process. Genetic engineering techniques that achieved the isolation of the enzyme gene led to an enormous increase in the availability of interesting enzymes.

patent application for the invention of zeolites. Zeolites were considered as an acceptable solution to the arising environmental issue and in 1975, the company was awarded a verification of environmental safety for their new product that led to the launching of phosphate-reduced product lines (e.g Prodixan in 1976). During the 1980s the Henkel gradually replaced its products, launched the phosphate-free Persil in Germany in 1986 and by 1988 had ceased the production of phosphate based detergents.

This is an illustrative example of research efforts being initiated by anticipation of public action and one that highlights the proactive behaviour of private actors that possess relevant technological expertise. Nevertheless and more interestingly, it is an example of unfulfilled expectations of legal action. Despite its importance the issue of eutrophication is still not regulated at European level[7], while national regulatory initiatives to ban the use of phosphates came later than the industry expected and did not match the economic costs of switching technology for the pioneers of this change. The substitute substance (zeolites), though more environmentally friendly, never matched the performance of tripolyphosphates, while an adequate substitute has not yet been invented. Whilst their use for laundry detergents has been significantly decreased, phosphates are still regarded an irreplaceable ingredient for automatic dishwashing. In the absence of European regulations, some Member States took the initiative to introduce bans on phosphates through national legislation[8] and 100% phosphate free in terms of consumption. These developments benefited producers of phosphate free detergents whose competitive status was again altered, this time on the basis of geographical/country differentiations.

The third concern related to the properties of detergents arose in the late sixties- early seventies, and is related to the use of enzymes as additives to the formulation. Although scientific studies have proved the ultimate biodegradability of enzymes due to their protein composition, these organic catalysts have been suspected of being related to respiratory allergies and asthma incidents affecting the work force on the sites of their production. Investigations in the late sixties attributed such phenomena to the dusty composition of both enzymes and detergent powders that allow enzymes to become airborne (Flindt, 1969: 1180). These findings resulted in legislation as well as protection measures applied in manufacturing plants, including the reduction of enzyme concentration and various safety measures in handling enzymes and limiting exposure (P&G, 2008).

7.3 From the 1970s onwards

[7] Arguments commonly used for retaining phosphates in detergents involve, firstly the minor contribution of detergents (comparing to agrochemicals) to the specific environmental issue and secondly, the possibility of solving the matter by improving water management technologies and not by replacing substances. This solution is indeed possible as currently such technologies exist but are nevertheless linked to increased operational costs, energy consumption and issues of phosphorus disposal (Kohler, 2001).

[8] Belgium, Germany, Ireland, Italy, Luxembourg, Netherlands, Austria (RPA, 2006b)

Following the outbreak of environmental and health and safety concerns resulting in respective legislation, the subsequent decades have mostly been characterised by the gradual but not total replacement of phosphate products, low foaming and low temperature detergents as well as the diffusion of liquid and gel-like detergents and the increased use of specialty chemicals (Frost and Sullivan, 2006). The eighties are similar in terms of the course of innovative efforts which were predominately focused on further differentiation of the product in terms of its use (development of specific products for kitchen and bathroom surfaces) and its form (i.e. concentrated forms and more aromatic liquid products). In the nineties, innovation can be characterised more as marketing and less as technological and focused on two rather conflicting targets; on one hand, the products were further differentiated in terms of their form (e.g. compact detergents and tablets) while, on the other hand, they were developed to serve the needs of a wider range of consumers following the 1992 Single European Act that officially signalled the integration of markets and the shift from a national to a European market focus (Dowdall, 1989). Further, antibacterial and disinfectant products were added to the production line and new markets were targeted, for instance schools and hospitals. Indicatively, between 1996 and 2002, the number of new anti-microbial products grew from 150 to more than 700 (Thomson Gale, 2006b) and the consumer market for disinfectants and anti-microbial was rising 6.1 percent a year in the early 2000s, compared to 3-4 percent growth in more established soap and detergent lines. In 2004 only, eleven new home anti-bacterial products were introduced in the market which was more than double the total for 2003 (ibid.).

From 2000 onwards, and given the global concerns on energy saving and the proliferation of legislation, innovative projects now aim at the development of detergents that perform well at lower temperatures as well as multipurpose products that meet the time limitations that contemporary consumers face. The continuous improvement of the product ignited by public concerns and respective public action becomes apparent considering the increasing claims of compliance published in the sector’s trade journals. Our search counted 8 articles announcing compliance technologies and generally describing the shift towards environmental friendly processes and technologies from January 2002 till December 2004 and 52 articles in issues covering the period January 2005-October 2008. In our view the quick (i.e. 1-3 years) technological and organisational responses to the requirements of the new regulations support the argument that firms’ efforts can be better explained by on the grounds of anticipation of regulatory changes rather than by a proxy of reaction to regulatory activity.The empirical evidence presented so far illustrates the continuous interaction between public action in the form of regulation and research efforts on the part of private agents. Relating to the emerging two-directional relationship between regulation and technological innovation, the three cases presented above illustrate on one hand instances in which technological advancements require respective institutional innovations in order to resolve emerging issues related to the use of new technologies. On the other hand they demonstrate that in the light of economic, social and legislative challenges companies tend to act proactively to demonstrate their willingness to allay consumers’ concerns and meet

market needs. Table 1 provides a synthetic overview of public and private actions marking the industry's evolution since the 1920s.

Table 1: Synthetic overview of innovations and regulations in the detergents industry

Time	Inventions	Innovations	Public Concerns	Legislation
Until the 1920s	Short chain alkyl suplhonates Sodium silicate and bleaches used as an additive to soap Sodium phosphates Enzymes for detergency (1914, marketed under the name “Burnus”)	Nekal for industrial use (textiles, Germany) Nacconol NR (dyeing industry, US) Persil (Henkel) Sodium phosphates in 1929 for dishwashing and laundry products		
1930s	Reduction of fatty acids to fatty alcohols produced sulphonated alcohols Non-ionic surfactants based on ethylene oxide Alkyl Aryl Sulphonates Sodium salt of carboxymethylcellulose (CMC)	Lissapol A (ICI, 1933, UK) Teelpol (Shell, 1942, UK) Igepons and Lissapol N Optical bleaches (ICI, 1937		
1940s		Alkyl benzene sulphonates made from propylene coupled with benzene (PT) Tylose (CMC developed by I.G. Farben) Synthetic detergents for domestic use		The 1943 UK *Soap Substitutes Labelling and Price Order*
1950s		Detergents with enzymes (Bio-40 , 1956)		

Time	Inventions	Innovations	Public Concerns	Legislation
1960s	Linear alkyl benzene sulphonate (LAS) to replace PT	Enzymes effectively incorporated in detergents (Biotex, 1963) Zeolites to replace phosphates (1966)	Foaming attributed to non-biodegradable PT	Dangerous substances directives
1970s		Phosphate free detergent brands (Sasil, Dixan, Liz)	Respiratory allergies and asthma incidents attributed to enzymes Euthrophication attributed to the use of STTP	Biodegradability for surfactants, Restrictions on Marketing and Use of certain chemicals
1980s		Reduction of enzyme concentration in detergents Product differentiation (liquids, gels, tablets, concentrated forms)		Notification system for new substances, Directives for assessment methods, ILO recommendation on classification and labelling
1990s		Product differentiation (liquids, gels, tablets, concentrated forms)		Existing substances regulation (targeting 141 substances) , Dangerous Preparations Directive, Review of existing legislation for detergents, Biocides Directive
2000 onwards		Product differentiation (liquids, gels, tablets, concentrated forms) Low temperature detergents		New Chemicals policy, Detergents Regulation, GHS (ongoing), Biocides Directive(ongoing)

8. Actors devising the co-evolution of regulation and innovation

Considering the evidence presented in the previous section, our next task is to ground empirically the argument that regulation cannot be considered as an externally imposed constraint on firms while the latter should not be viewed as mere respondents to the requirements of new regulations. This task is deployed in this section and draws on evidence of the proactive nature of actors' behavior, who driven by anticipation and motivated by their interest to influence the outcome of the process and adjust to the new requirements, act proactively and strengthen their status through collaborations and information exchange.

Considering the structure of the European policy system and the regulatory process discussed in Section Six, actors are aware of the opportunities offered to participate and present their opinions on forthcoming changes. The activity of actors, especially industry, is not constrained to the formal consultation process, nor commences with the announcement of the authorities intentions to regulate. Rather, it is initiated prior to regulatory activity and is expressed through both technological and organizational proactive responses. Proactive technological responses were discussed in the preceding section; this section focuses primarily on the latter. Both, in the case of biodegradable surfactants and of phosphate free detergents, the substitute technologies and the testing methods were developed by firms in anticipation of public intervention and accompanied by market incentives. Expertise and technological know-how of firms regarding biodegradability and generally the properties of ingredient substances started to evolve and accumulate from the very early days of the industry and ensured credibility of firms' positions when negotiating with the authorities on the technical aspects of the issue.

In the seventies, another group of stakeholders entered the scene; environmentalist groups were a global phenomenon of the 1970s and foaming events provided good opportunities to express environmental concerns and cast doubts on the operations of the industry through negative publicity. The industry's response to public concerns and bad publicity about its products was almost immediate and expressed through strategic innovations. Indicatively, it was in 1972 that the CEO of Henkel, in a public statement, talked about the cost and benefits of future generations and the company's willingness to make efforts for the development of environmentally friendly products. Although the industry should not be considered as a single stakeholder, in the case of detergents, action by a representative part of the industry towards collective activity for new, improved products as well as strategic communication with the authorities was driven by consensus. Firms realized that the chances of improving their innovative performance by actively participating and, to an extent, shaping policy and regulatory developments would be far better than by relying only on internal decision making as a response to governmental action.

By the end of the eighties, and given the proliferation of firms entering the European political system due to the enlargement of the European Community, collective action among the leading firms of the sector became more obvious and official. In 1989, a voluntary agreement on the labelling of detergents was signed between the European

Association for Soaps and Detergents and the European Commission at European level and between the national detergents associations and the respective ministries at national level. This was followed by a number of voluntary initiatives organized by the industry (see BOX 1) that chronologically precede the actual announcement of the authorities to review the existing legislation on detergents and chemicals in general. Although initiated by rationales of cost and information sharing, these initiatives had more important results. Firstly, they created new knowledge regarding risk assessment methods, knowledge that was then diffused not only among the participating stakeholders but across the whole industry, thus increasing its capacity for the development and assessment of products that comply with regulatory requirements. Secondly, the expertise developed on technical issues as well as the successful planning, management and administration of consortia and other collaborative activities established the role of the industry in the process of regulatory reform and equipped them with a very credible and influential voice when negotiating with the Commission about other pieces of legislation. The first implication is illustrated with the examples of industry framework programs and strategic partnerships while the second is contextualized in the case of consortia created within the industry to deal with the requirements of the Detergents Regulation.

BOX 1: VOLUNTARY INDUSTRY INITIATIVES

1991: ERASM (Environmental Risk Assessment and Management), a joint AISE/CESIO initiative, www.erasm.org

1998: Washright Campaign, AISE initiative providing a Code of Good Environmental Practice for household laundry detergents. www.washright.com

1999: HERA (Human & Environmental Risk Assessment) project on ingredients of household cleaning products, joint AISE/CESIO initiative, www.heraproject.com

2001: DUCC (Downstream users of Chemicals Co-ordination Group), a platform to address REACH's objectives, http://www.duccplatform.org/home.html

2004: AISE Charter of Sustainable Cleaning, a voluntary initiative of the Soaps, Detergents and Maintenance products industry, http://www.sustainable-cleaning.com/home.orb

2005: PRODUCE, a strategic partnership Piloting REACH on Downstream Use and Communication in Europe, www.producepartnership.be

Source: AISE, 2007

8.1. Creation and diffusion of new knowledge: Industry Framework Programs and strategic partnerships

The Charter for Sustainable Cleaning[9] was launched in 2004 and covers production in the EU-25 area plus Norway, Switzerland and Iceland. In order for companies to become members, they need to implement in their management systems the outlined methods included in the Charter Sustainability Procedures and agree to be independently verified for the Charter entrance check. The Charter had 8 registered firms in 2004[10] while by 2008 the members' list had expanded to 70 companies. Member companies report their progress against a set of key performance indicators (KPIs) on a yearly basis, enabling the Association to publish an annual report that demonstrates the contribution being made by the European cleaning products industry towards international sustainability targets. To date, three reports have been compiled and published offering information about initiatives across Europe as well as updates on the KPIs.

HERA[11] is a voluntary industry program which aims to carry out Human and Environmental Risk Assessments on ingredients of household cleaning products. A partnership between the association of household cleaning products (A.I.S.E) and the chemical industry association (CEFIC) resulted in the launch of the program in 1999, two years before EU Authorities announced the revision of the Chemicals Policy in 'White Paper' presented in February 2001. The launch of the initiative was driven by the increasing demand for the provision of information, the associated tensions along the supply chain, the existing risk assessment legislation and the anticipation of additional forthcoming regulatory action. Its objective is expressed as the need to "*provide a common risk assessment framework for the household cleaning products industry, and show that this process will deliver evaluated safety information on the ingredients used in these products in an effective and transparent way"* (ibid.). With regards to the creation and diffusion of new knowledge, the first stage of the project involved negotiations on the procedures between the supplier and formulator companies, development of a common methodology for risk assessment and completion of assessments on three pilot chemicals. The results were then internally reviewed and discussed with experts in science - regulators and academia - as well as representatives of consumer and other non-governmental organizations in order for the methodology to be applied to all relevant substances used in household cleaning products. By 2005, the project completed comprehensive risk assessments on more than 250 chemical substances, covering more than 90% of the total tonnage of chemicals used in detergent and household cleaning products in Europe. In addition to the evident knowledge and expertise added to the participants of the project as well as the industry as a whole, the project contributed to the establishment of stronger collaborative links within the industry. Accordingly, in the retrospective report on the project in the title "Five years ahead of REACH" published in 2005 (p.4) it is stated that "*HERA has developed some unique principles of working and of cooperation between industry partners (e.g. partnership between manufacturers and users, data sharing, risk assessment approach,*

[9] Information on the initiative can be found at http://www.sustainable-cleaning.com/home.org

[10] The first companies to achieve membership status in 2004 were Henkel, Johnson Diversey, McBride, Procter & Gamble, Reckitt Benckiser, Unilever, Nice-Pack and Sucitesa

[11] Information on the initiative can be found at www.theheraproject.com

one assessment per substance, open dialogue, transparency, etc.) that, we believe, have lasting value and that could serve as a model of cooperation to other industry sectors of the chemical industry in the future[12]".

8.2. Enhancing bargaining power: information sharing consortia and forums

An important implication of the 2004 Regulation was the obligation of firms to provide information about their testing methods for the biodegradability and safety of their products. The need to fill out and submit the respective information dossiers and the fact that this sort of information is located in the firms manufacturing the ingredient substances for detergents, resulted in the creation of consortia among manufacturing companies aiming at cost and data sharing as well the prevention of duplicated efforts. A list was created with all substances of interest; firms would then register the available testing studies which could be exchanged or sold. Information about who owned the study or the price[13] of exchange was not accessible. Hence, if one company was interested in acquiring a specific study, it would have to express its intention to exchange or buy information to the industrial association (CESIO). The latter had the intermediary role of bringing the interested two parties in contact.

This "pair wise" mode of operation (Baumol, 2001) gave some guarantee that fixing prices or agreements to hold R&D outlays low will be avoided. These consortia were successful in fulfilling the requirements placed by the new regulatory framework and their success is attributed to the long tradition of cooperation between the member firms, which, although fiercely competing in the product market, joined forces to deal efficiently with the regulatory provisions. Certainly the "mini markets of studies" created by the consortia acted as an incentive for firms to invest time in conducting the testing required since the first company to achieve the test results could then sell them for a negotiable price.

The example set by the consortia formulated in response to the 2004 Detergents regulation has acquired the characteristics of a best practice among firms in the industry and has been diffused as an efficient method for meeting regulatory requirements in less time and with decreased costs. The establishment of several industry consortia within the industry in response to an increasing number of legislations is common knowledge to the regulators and policy makers, who (especially the Unit dealing with detergents in DG Enterprise), welcome this intervention of the industry that contributes to a general tendency for closer collaboration between the authorities and the industry. Indicatively, "*partnering with authorities and other stakeholders*" is one of the three strategic pillars of the European Association for Detergents and Soaps in their effort to shape the formulation of regulation in a way that supports their agenda.

The case of REACH also illustrates how the industry's proactive nature, combined with the opportunities offered by the participatory character of the current system, enhances

[12] CEFIC, AISE, 2005, available at http://www.heraproject.com/files/HERA_reference_v51%20FINAL%20amended.pdf

[13] The average price of a study would be around € 2500 which would be negotiable depending on what is on offer from the two sides (exchange is also possible depending on the available material)

the bargaining power of the private sector. Of particular interest in this case is the policy makers' decision to create Substance Information Exchange Fora (SIEF) and was intended to operate on the same basis as the type of consortia presented above. Delays in its planning attributed to the variety of cases were tackled by industry representatives who acting proactively and in close collaboration with the authorities supported and organized the formation of pre-REACH that were later used as platforms. The participation in SIEF means that when a company registers a substance, the information contained in the registration dossier is automatically transferred onto an online database and is made available (at least until 2013) upon request to all other companies that have registered a substance and hence have access to SIEF. The main difference between SIEF and the consortia created as voluntary initiatives is that participation is now compulsory and hence so is data sharing. Thus, a voluntary collective activity of the industry has been transformed into a rule of implementation for a much broader policy and still private actors lead the developments. The implications of such a measure involve the obvious benefits of cost sharing, avoidance of duplicated testing and hence reduction of animal-testing. Further, and more importantly for this study, there are indirect implications for innovation considering that information dissemination and collaboration are indispensable factors of innovation.

The empirical findings presented above suggest that anticipation of public intervention and rising public awareness lead to improvements of the existing technologies and the quest for alternatives. At the same time, new technologies render old regulations obsolete and induce regulatory reforms. Due to the changing pattern of government and industry relationships, information sharing and collaboration become essential or unavoidable and this impacts on the manner in which the innovation process is organized. Whilst the motive of collaboration might not always be explicitly linked to innovation, we find that the information exchanged is regarded as valuable and can fuel innovation. In addition to knowledge diffusion achieved by the establishment of coalitions (in any form), a further important implication is the ability of actors to influence the outcome of the policy process. Hence, the opportunity given to actors to influence their institutional environment through their active participation in the regulatory process contributes to the improvement of their knowledge and, consequently, bargaining power (due to information sharing facilitated by coalitions[14]). In turn, these attributes improve respectively their innovative potential and ability to further influence their institutional surrounding. Favorable institutional conditions have been recognized as a factor conductive to innovation and, in this sense, we can witness a circular and interactive relationship between the regulatory and innovation process. The anticipation of regulation triggers firms' interest to influence their institutional environment while they become more knowledgeable and capable of conducting innovation and altering their institutional surroundings. Certainly there is a time lag between technological advancements and public action which is explained by the fact that issues emerge only with experience due to the inherent uncertainty entailed in the innovation process.

[14] This pattern might present similarities to what Chesbrough (2003) refers to as open innovation, however further research needs to be conducted in order to conclude to such argument.

9. Conclusion

This paper argues that the innovation and regulation processes are evolutionary processes that interact overtime and their co-evolution is facilitated by knowledgeable and purposeful agents who wish to influence their institutional environment. Existing accounts explaining the relationship between regulation and innovation have tended to treat regulation as an exogenously posed impediment on innovation to which private agents react after its promulgation. Gaining distance from such approaches we consider regulation as an enabling endogenously generated institution that goes beyond disciplining and controlling agents' activities and is able to contribute to the transformation of economic and non-economic social relations, facilitate economic coordination and reduce uncertainty.

With regards to approaches analyzing the implications of regulation to innovation we find that, notwithstanding their value for establishing and grounding the relationship between regulation and innovation, they sketch a linear view of policy impact on economic processes where public policies are considered as formulated away from economic agents, are then announced and have single-directional effects on economic development (as this is driven by innovation). This is a view we wish to refrain from and in doing so we build upon accounts that argue for an interactive relationship between regulation and innovation that is facilitated by the proactive behavior of purposeful economic and non-economic agents. Towards this avenue political science accounts analyzing the policy process through an evolutionary lens provide helpful insights to comprehend how the two processes interact and prove the resemblance of the policy process to the innovation process.

This study is empirically contextualized in a political system that induces collaboration and favors multi-actor participation on the policy process and in a concentrated industry whose evolution has been led by technological advancements. This context assisted to reveal the circular, continuous and interactive relationship between regulation and innovation. More specifically we found that actors act proactively to legal change and are able to influence the outcome of the regulatory process. The opportunity provided to private actors to participate in the process, share information and collaborate, contributes to the improvement of their knowledge. In turn, improved knowledge increases the innovative potential of actors while it builds their bargaining power and increases the possibilities private actors have to influence their institutional environment. Favorable institutional conditions have been recognized as a factor conductive to innovation and in this sense, we can witness a circular and interactive relationship between the regulatory and innovation process; namely, the anticipation of regulation triggers firms' interest to influence their institutional environment while they become more knowledgeable and capable of conducting innovation and altering their institutional surroundings. Certainly there is a time lag between technological advancements and public action which is explained by the fact that issues emerge only with experience due to the inherent uncertainty entailed in the innovation process.

The findings of this paper highlight that the value of accumulated knowledge is not only manifested in new technological achievements, which is the main argument of the majority of innovation studies. This paper points to the value of knowledge as a potential key to enter the policy process and reduce possible negative implications for the operations and innovative potential of firms through active participation and the collaboration with other agents.

Certainly the methodological approach of this study does not allow generalizations; nevertheless, it opens the way to conducting interesting comparative analyses between sectors and/or between political systems.

References

Abraham, J. and Reeds, T., 2002, Progress, Innovation and Regulatory Science in Drug Development: the politics of international standard setting, *Social Studies of Science* 32, 337-369

AISE, 2007, Annual Review, (AISE, Brussels).

AISE, CEFIC, 2008 The HERA (Human and Environmental Risk Assessment), online available at http://www.heraproject.com and http://www.heraproject.com/files/HERA_reference_v51%20FINAL%20amended.pdf [Accessed 15th May 2008]

Andersen, B. and Walsh, V., 2000, Co-evolution within chemical technology systems: a competence bloc approach, *Industry and Innovation* 7, 77-115.

Ashford, N and Heaton, G., 1983, Regulation and technological innovation in the chemicals industry, *Law and Contemporary Problems* 46, 109-157

Bernstein, M., 1955, *Regulating Business by Independent Commission* (Princeton University Press, Princeton)

Blind, K., 2004, *New products and services: Analysis of regulations shaping new markets*, (Fraunhofer, ISI, DG Enterprise, Karlsruhe)

Broscheid, A. and Coen, D., 2007, Lobbying activity and fora creation in the EU: empirically exploring the nature of the policy good, *Journal of European Public Policy* 14, 346-365

Broscheid, A., and Coen D., 2003, Insider and Outsider lobbying of the European Commission, *European Union Politics,* 4, 165-189

Bouwen, P., 2001, Corporate lobbying in the European Union: towards a theory of access, *EUI Working Paper* No. 2001/5

Burns, T.R. and Flam, H., 1987, *The Shaping of Social Organization: Social Rule System Theory with Applications* (Sage, London)

Carlsson, B. and Stankiewicz, R., 1991, On the nature, function and composition of technological systems, *Journal of Evolutionary Economics,* 1, 93-118

Carlsson, B., 2002, The analytical approach and methodology, in B. Carlsson, ed.: *Technological systems in the bio-industries: an international study* (Kluwer Publishers)

Chen, B.Y and Wang, H.T, 2008, Utility of enzymes from Fibrobacter succinogenes and Prevotella ruminicola as detergent additives, *Journal of Industrial Microbiology and Biotechnology* 35, 923–930

Cimoli, M., G. Dosi, R. Nelson, and J. Stiglitz, 2006, Institutions and Policies Shaping Industrial Development: an introductory note, *LEM Working Paper Series*, (Laboratory of Economics and Management Sant'Anna School of Advanced Studies)

Coen, D., 1997, The evolution of the large firm as a political actor in the European Union, *Journal of European Public Policy* 4, 91-108

Coen, D., 2007, Empirical and theoretical studies in EU lobbying, *Journal of European Public Policy* 14, 333-345

Corlett, W.J., 1958. *The Economic Development of Detergents* (Wyman and Sons, London)

Crombez, C., 1997, The co-decision procedure in the European Union, *Legislative Studies Quarterly* 22, 97-119

Crombez, C., 2002, Information, Lobbying and the legislative process in the European Union, *European Union Politics* 3, 7-32

Depret, M.H and Hamdouch A., 2000, Innovation networks and competitive coalitions in the pharmaceutical industry: The emergence and structures of a new industrial organization, *European Journal of Economic and Social Systems* 14, 229-270

Dopfer, K., Foster, J. and Potts, J., 2004, Micro-meso-macro, *Journal of Evolutionary Economics* 14, 263-279

Davidsohn, A. and Milwidsky, B.M, 1967, *Synthetic Detergents* (Leonard Hill, London)

Dosi, G. and Nelson, R.R, 1994, An introduction to evolutionary theories in economics, *Journal of Evolutionary Economics* 4, 153-172

Dosi, G., 1982, Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change, *Research Policy* 6, 147-162.

Dowdall, M., 1989, The challenge of the Single Market for Company Strategy, *Admap Magazine,* 25, 6, 10-13

Eads, G.C., 1980, Regulation and Technical Change: Some Largely Unexplored Influences, *The American Economic Review,* 70, 50-54

Eckardt, M., 2004, Evolutionary Approaches to Legal Change*, Thünen-Series of Applied Economic Theory,* Working Paper No. 47*,* (Rostock University)

Edler, J., and Georghiou, L., 2007, Public procurement and innovation--Resurrecting the demand side, *Research Policy* 36, 949-963

Edwards, H.R., 1962. *Competition and Monopoly in the British Soap Industry* (Oxford University Press)

Eising, R., 2007, The access of business interests to EU institutions: towards elite pluralism?, *Journal of European Public Policy* 2007, 14, 3, 384-403

Eisner, 2004, Corporate Environmentalism, Regulatory Reform, and Industry Self-Regulation: Toward Genuine Regulatory Reinvention in the United States, *Governance* 17, 145 - 167

EUR-Lex, 2008, website, http://eur-lex.europa.eu/en/index.htm [Last Accessed 19th August 2008]

Euromonitor, 2005, *The World Market for Household Care*, Euromonitor International

Francis, GJ, 1993, *The politics of regulation: a comparative perspective* (Blackwell, Oxford)

Flindt, M. L. H., 1969, Pulmonary Disease due to inhalation of derivatives of bacillus subtilis containing proteolytic enzyme, (The Department of Occupational Health, University of Manchester)

Freeman, C. and Perez, C., 1988, Structural crisis of adjustment, business cycles and investment behaviour, in G. Dosi, Freeman, C., Nelson, R., Silverberg, G., Soete, L. , ed.: *Technical Change and Economic Theory* (Pinter, London).

Frost and Sullivan, 2006, European Markets for Home Care Ingredients, No B917-39 (Frost & Sullivan Ltd, London)

Geels, F. W., 2002, Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study, *Research Policy* 31, 1257-1274

Geels, F. W., 2004, From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory, *Research Policy* 33, 897-920

Georghiou, L., Metcalfe, J.S, Gibbons, M., Ray, T. and Evans, J., 1986, *Post-innovation performance: technological development and competition* (Macmillan, London).

Grande, E., 2001, *Institutions and Interests: interest groups in the European System of multi-level governance*, Working Paper, N. 1/2001, Chair for political science (TU Munich).

Gupta, R., Beg, Q.K. and Lorenz, P., 2002, Bacterial alkaline proteases: molecular approaches and industrial applications, *Applied Microbiology and Biotechnology* 59:1, 19-32

Gulati, R., 1995, Social structure and alliance formation patterns: a longitudinal analysis *Administrative Science Quarterly* 40, 619-652

Heine, K., and Kerber, W., 2002, European Corporate Laws, Regulatory Competition and Path Dependence, *European Journal of Law and Economics* 13, 47-71.

Henkel, 2007, Innovation Letters, online, available at, http://www.henkel.com/cps/rde/xchg/henkel_com/hs.xsl/11970_COE_HTML.htm [Accessed 3rd July 2008]

Hix, S., 2005, The *Political System of the European Union* (Palgrave, Basingstoke)

Hogwood, B. and Gunn, L., 1984, *Policy Analysis for the Real World* (Oxford University Press)

Hughes, T.P., 1983. *Networks of Power, Electrification in Western Society, 1880-*

Irwin, A., and P. Vergragt, 1989, Re-thinking the relationship between environmental regulation and industrial innovation: the social negotiation of technical change, *Technology Analysis & Strategic Management* 1, 57-70

Jaffe, A. and Palmer, K., 1997, Environmental regulation and innovation: A panel data study, *Review of Economics and Statistics* 79, 610-619

Jaffe, A., and Stavins R.N., 1995, Dynamic Incentives of Environmental Regulations: The Effects of Alternative Policy Instruments on Technology Diffusion, *Journal of Environmental Economics and Management* 29, 43-63

Jessop, B., 1995, The Regulation Approach, Governance, and Post-Fordism: Alternative Perspectives on Economic and Political Change, *Economy and Society* 24:3, 307-333

John, P., 1998. *Analysing Public Policy* (Continuum, London)

Jordana, J. and Levi-Faur, D., 2004, *The Politics of Regulation: Institutions and Regulatory Reforms for the Age of Governance* (Edward Elgar, Cheltenham)

Kemp, R., Smith, K. and Becher, G., 2000, How should we study the relationship between environmental regulation and innovation?, in JRC-IPTS and Enterprise DG, ed.: The impact of EU regulation on innovation of European

Kirk, O., Borchert, T.V. and Fuglsang, C.C., 2002, Industrial enzyme applications, *Current Opinion in Biotechnology* 13, 345-351

Klemmer, P., 1999, *Innovation effects of environmental policy instruments* (Analytica, Berlin)

Knill, C., 2001, Private governance across multiple arenas: European interest associations as interface actors, *Journal of European Public Policy* 8, 227-246

Kohler, J., 2001, Detergent phosphates and detergent ecotaxes : a policy assessment, in Centre Européen d'Etudes des Polyphosphates, ed.: (European Chemical Industry Council (CEFIC)).

Kuhn, T., 1970, *The Structure of Scientific Revolutions* (Chicago Univeristy Press, Chicago)

Lengrand L. and Associés, PREST, ANRT, 2002, *Innovation tomorrow - Innovation policy and the regulatory framework: Making innovation an integral part of the broader structural agenda*, Innovation papers No 28, (Directorate-General for Enterprise, Luxembourg).

Leydesdorff, L. and Etzkowitz, H., , 1996, Emergence of a Triple Helix of University-Industry-Government Relations, *Science and Public Policy* 23, 279-286

Loasby, B., 1999. *Knowledge, Institutions and Evolution in Economics* (Routledge, London)

Lundvall, B.A., 1988, Innovation as an interactive process: from user-producer interaction to the national system of innovation, in G. Dosi, Freeman, C., Nelson, R., Silverberg, G., Soete, L., ed.: *Technical Change and Economic Theory* (Pinter, London)

Määttä, K., 2001, Regulatory reform and innovations: Whether to trust the invisible hand or use the visible one?, (Sitra, Helsinki)

Majone, G., 1996, *Regulating Europe* (Routledge, London)

Malerba, F., 2002, Sectoral systems of innovation and production, *Research Policy* 31, 247-264

McKelvey, M., 1996, *Evolutionary Innovations: the business of biotechnology* (Oxford University Press, New York)

Metcalfe, J. S. and Foster, J., 2004, *Evolution and Economic Complexity* (Edward Elgar, Cheltenham)

Mintel, 2007, Household Cleaning Products – UK, Mintel International

Modelski, George, 1996, Evolutionary Paradigm for Global Politics, *International Studies Quarterly* 40, 321-342

Nelson R.R, Winter S.G., 1982. *An evolutionary theory of economic change* (Belknap Press, Cambridge, London)

Nelson, R.R. and Winter, S., 1977, In search of useful theory of innovation, *Research Policy* 6, 36-76

Nelson, R.R., 1994, The Co-evolution of Technology, Industrial Structure, and Supporting Institutions, *Industrial and Corporate Change* 3, 47-63

Nelson, R.R., 1995, Recent evolutionary theorizing about economic change, *Journal of Economic Literature* 33, 48

Nelson, R.R., 2000, Selection Criteria and selection processes in cultural evolution theories, in J. Ziman, ed.: *Technological innovation as an evolutionary process,* (Cambridge University Press, Cambridge)

Nonaka, I., and Kenney, M., 1991, Towards a new theory of innovation management: A case study comparing Canon, Inc. and Apple Computer, Inc, *Journal of Engineering and Technology Management* 8, 67-83

Kivimaki, M., Lansisalmi, H., Elovainio, M., Heikkila, A., Lindstrom, K., Harisalo, R., Sipila, K., and Puolimatka, L., 2000, Communication as a determinant of organizational innovation, *R&D Management* 30, 33-42

North, D., 1990. *Institutions, Institutional Change and Economic Performance* (CUP, Cambridge)

Oliver, M., 2005, Ex*planatory Memorandum to the Detergents Regulations 2005 No 2469*, (DEFRA)

Osborn, R. N., and Hagedoorn, J., 1997, The Institutionalization and Evolutionary Dynamics of Inter-organizational Alliances and Networks, *The Academy of Management Journal* 40, 261-278

Palmberg, C., 2004, The sources of innovations: looking beyond technological opportunities, *Economics of Innovation and New Technology in Society* 13, 183-197

Peet, J., 2007, Beyond the regulation approach: putting capitalist economies in their place *Journal of Economic Geography* 7, 118-119

Pierson, P., 2000, Increasing Returns, Path Dependence, and the Study of Politics, *The American Political Science Review* 94, 251-267.

Pierson, P., 1993, When effect becomes cause: Policy feedback and political change, *World Politics 45*, 595-628

Posner, R.A., 1974, Social Costs of Monopoly and Regulation, NBER Working Paper No W0055, (University of Chicago Law School, National Bureau of Economic Research (NBER))

Powell, W, Koput, K and Smith-Doerr, L, 1996, Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology, *Administrative Science Quarterly* 41, 116-145

Procter and Gamble, (P&G), 2008, Enzymes, online, available at http://www.scienceinthebox.com/en_UK/safety/whatareenzymes_en.html [Accessed 23rd March 20008]

Rip, A. and Kemp, R., 1998, Technological change, in S. and Malone Rayner, E.L., ed.: *Human Choice and Climate Change* (Battelle Press, Columbus)

Rodriguez, V. and Montalvo, C., 2007, Innovation Policies From the European Union: Methods for Classification, *Bulletin of Science Technology Society* 27, 467-481

Rosenberg, N., 1969, The direction of technological change: Inducement Mechanisms and Focusing Devices, *Economic Development and Cultural Change* 18, 1-24

Ronit, K., and Schneider, V., 1999, Global Governance through Private Organizations, *Governance* 12, 243-266

Rubin, P., 2002. *Darwinian politics: the evolutionary origin of freedom* (Rutgers University Press).

Sahal, D., 1985, Technological guideposts and innovation avenues, *Research Policy* 14, 61-82

Salisbury, Robert H., 1984, Interest Representation: The Dominance of Institutions, *The American Political Science Review* 78, 64-76

Saviotti, P. and Metcalfe, J.S, 1984, A theoretical approach to the construction of technological output indicators, *Research Policy* 13, 141-151

Scailteur, V., 2001, The impact of REACH, ppt presentation in EUROPA - Enterprise - Stakeholder Workshop on Extended Impact (Brussels)

Scharpf, F., 1997, Introduction: the problem solving capacity of multi-level governance, *Journal of European Public Policy* 4, 520-538.

Shaffer, B, 1995, Firm-level responses to governmental regulation: theoretical and research approaches, *Journal of Management* 21, 495-514

Slembeck, T., 1997, The Formation of Economic Policy: A Cognitive-Evolutionary Approach to Policy-Making, *Constitutional Political Economy* 8, 225-254

Sotarauta, M., and Srinivas, S., 2006, Co-evolutionary policy processes: Understanding innovative economies and future resilience, *Futures* 38, 312-336.

Stankiewizc, R., 2000, The concept of "design space", in J. Ziman, ed.: *Technological Innovation as an evolutionary process* (Cambridge University Press, Cambridge)

Stankiewizc, R., 2002, The cognitive dynamics of biotechnology and the evolution of its technological systems, in B. Carlsson, ed.: *Technological systems in the bio-industries: an international study* (Kluwer Publishers)

Steward, F., and Wibberley, G., 1980, Drug Innovation-what's slowing down?, *Nature* 284, 118-120

Stigler, G., 1975. Citizens and the State: Essays on Regulation (University of Chicago Press, Chicago).

Stigler, G.J, 1971, The theory of economic regulation, *Bell Journal of Economics and Management Science* 6, 3-21

Teece, D., 1994, Information Sharing, Innovation and Anti-trust, *Antitrust Law Journal* 63, 465-481

Thomson Gale, 2006a, American Industry Overview: Soap and Other Detergents, Except Specialty Cleaners, Encyclopaedia of American Industries.

Thomson Gale, 2006b, Emerging Industry Overview: Anti-bacterial Products, Encyclopaedia of Emerging Industries.

Thomson Gale, 2006c, Global Industry Overview: Soaps and Detergents, Encyclopedia of Global Industries

von Tunzelmann, N., 2003, Historical co-evolution of governance and technology in the industrial revolutions, *Structural Change and Economic Dynamics 14*, 365-384

Wilson, J., 1980, *The Politics of Regulation* (Basic Book Inc, New York)

Witt, U., 2003, Economic policy making in evolutionary perspective, *Journal of Evolutionary Economics* 13, 77-94

Woll, C., 2006, Lobbying in the European Union: from sui generis to comparative perspective, *Journal of European Public Policy* 13, 456-469

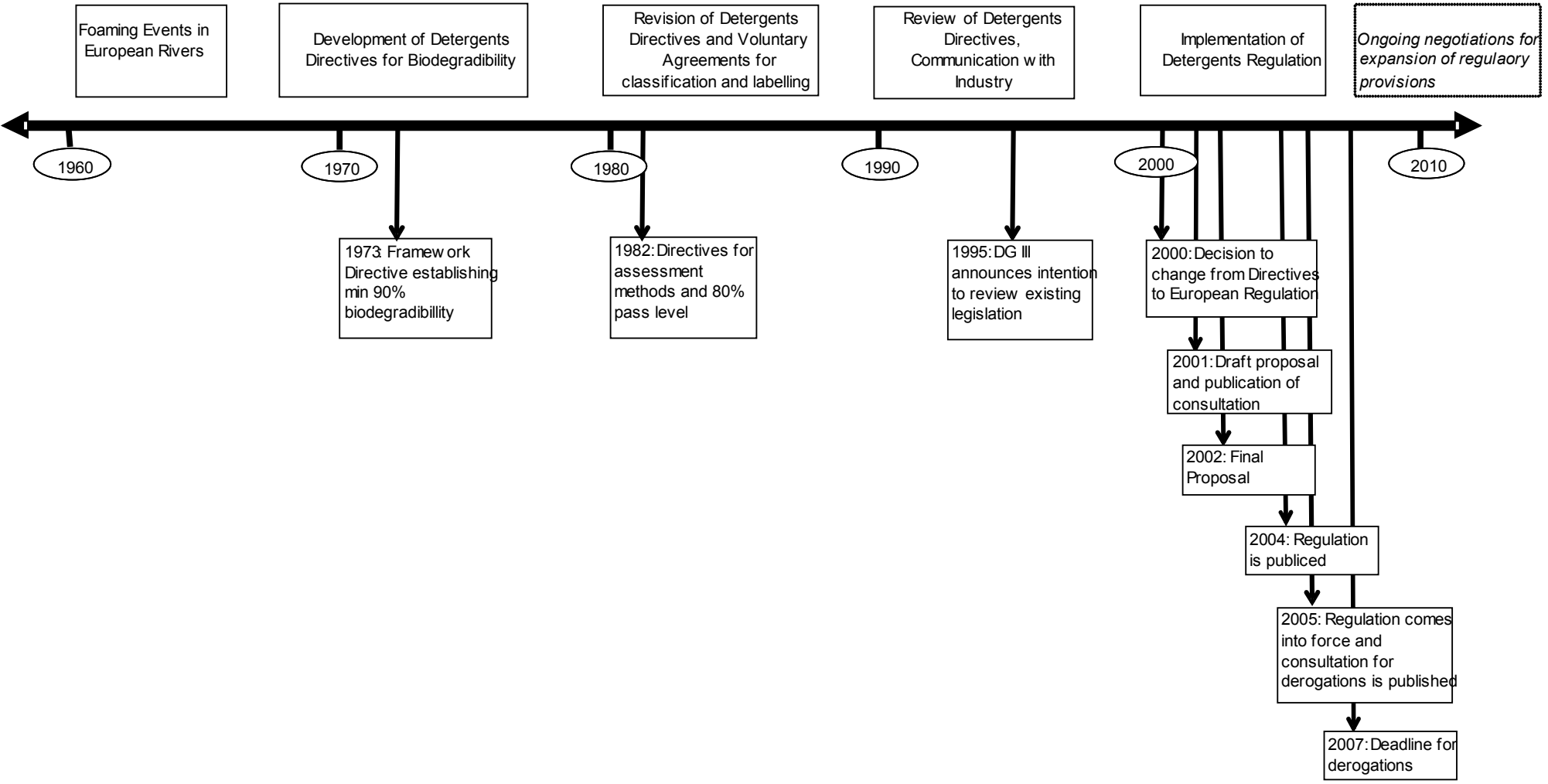
Ziegler, H., 1964, *Interest Groups in American Society* (Prentice-Hall, Englewood Cliffs)

ANNEX 1: The Co-Decision Process[15]

[15] http://ec.europa.eu/codecision/stepbystep/text/index_en.htm

ANNEX 2: THE 2004 DETERGENTS REGULATION

The 2004 Detergents Regulation is the improved and expanded descendant of the 1973 Framework Directive on Biodegradability promulgated by the European Authorities and is an indicative case of smooth legislative succession supported by collaboration between authorities and industry. Its policy aim was described as “ensuring the free movement of detergents and surfactants for detergents in the internal market and a high degree of protection of the environment and human health” (EC 648/2004). The latest review of existing legislation aimed to meet global environmental targets, consider technological advancements related to the product, formalize existing voluntary agreements and level regulatory differences among Member States. The 2004 Detergents Regulation introduced a new testing regime on the biodegradability of surfactants while it distinguished requirements for surfactants for domestic use on one hand and industrial/institutional applications on the other. According to the legal test, surfactants for domestic use that fail to pass the stringent biodegradability test have to be withdrawn from the market unless the manufacturers are granted derogation by the European Commission. Apart from the tighter biodegradability testing requirements for the active ingredients of detergents, the regulation requires fuller contents information to be provided on detergents labels and repeals the previous legislation on detergents (Directives: 73/405, 73/405, 82/242, 82/243, 86/94 and Recommendation 89/542) (Oliver, 2005). Initiated in 2001, the formulation of the new regulation followed the co-decision process. This was also the year when consultations were incorporated formally in the European regulatory process and hence the opinion of different stakeholders was officially requested. The figure below presents the legislative background of the 2004 Detergents Regulation.


Foaming Events in European Rivers
Development of Detergents Directives for Biodegradibility
Revision of Detergents Directives and Voluntary Agreements for classification and labelling
Review of Detergents Directives, Communication with Industry
Implementation of Detergents Regulation
Ongoing negotiations for expansion of regulaory provisions
1960
1970
1980
1990
2000
2010
1973: Framework Directive establishing min 90% biodegradibillity
1982: Directives for assessment methods and 80% pass level
1995: DG III announces intention to review existing legislation
2000: Decision to change from Directives to European Regulation
2001: Draft proposal and publication of consultation
2002: Final Proposal
2004: Regulation is publiced
2005: Regulation comes into force and consultation for derogations is published
2007: Deadline for derogations

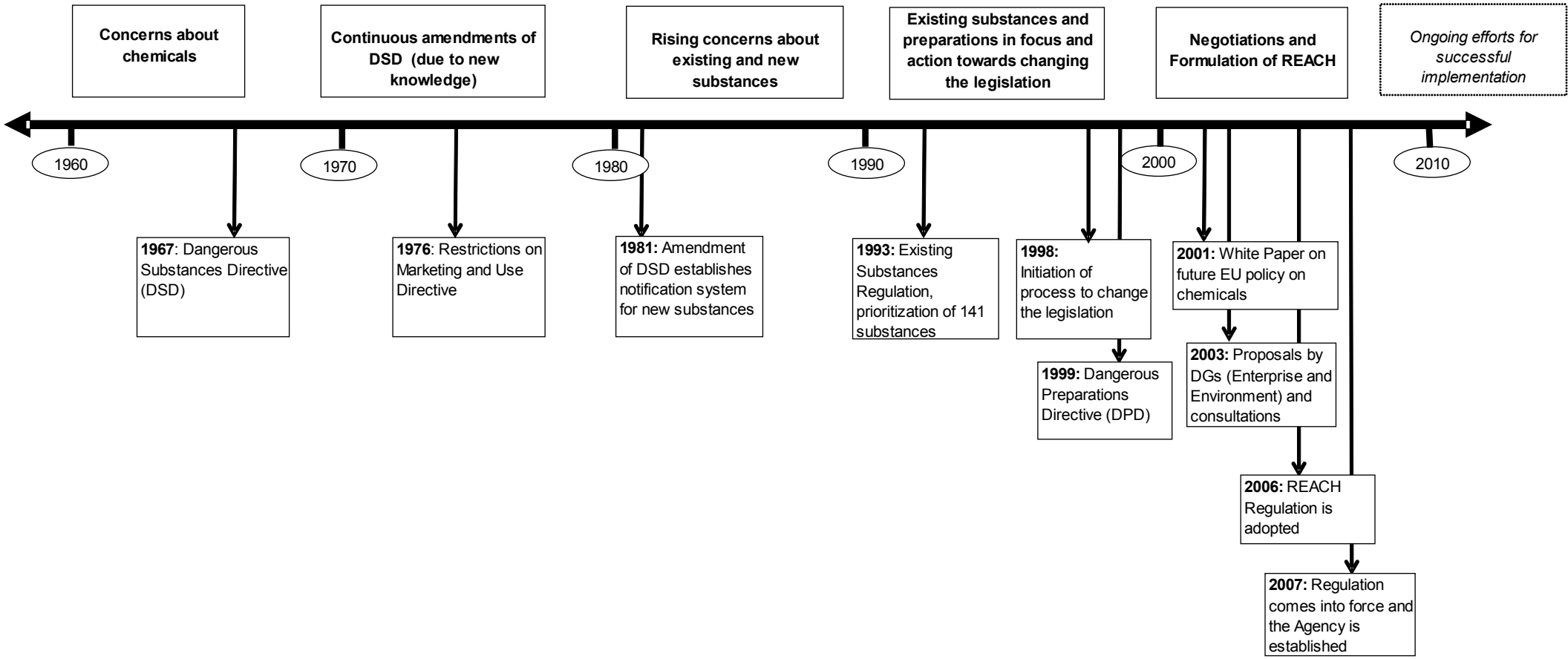
ANNEX 3: Registration, Evaluation, Authorization and Restriction of CHemical substances (REACH)

The new Chemicals Regulation deals with the Registration, Evaluation, Authorization and Restriction of CHemical substances (REACH) (EC 1907/2006). REACH affects the whole chemical industry and respectively the detergents sector while it consolidates and harmonizes the hitherto national and European pieces of legislation regulating chemical substances. REACH is the descendant of the Dangerous Substances Directive of 1967 (67/548/EC), which was reviewed several times mainly with regards to its annexes. Briefly, the development of this regulation occurred as follows. The 1981 6th Amendment of the Dangerous Substances Directive made compulsory the notification of new substances to a system that required testing and risk assessment prior to their marketing. In 1993, the Existing Substances Regulation (ESR) prioritized 141 (out of 30,000) substances for comprehensive risk assessments based on rising concerns about existing substances. The ESR provided guidelines for the testing, risk assessment and risk management of existing substances based on existing data without further requirements. In 1999, the Dangerous Preparations Directive (DPD) filled the gaps of the Dangerous Substances Directive (DSD), by regulating preparations and finished products accompanied by the 2001 General Product Safety Directive which sets safety requirements for consumer products and is of a very wide scope.

The above regulation placed most of its emphasis on new chemicals and much less on the existing ones. In April 1998, the Council of Environment initiated the process for changing the legislation. Since 1998 and for most of the following three years there has been increased activity on the part of the authorities, including consultations with relevant stakeholders as well as preparation of reports and formal texts. In 2001, an EC White Paper titled “Sustainable Development in the EU Chemical industry within the framework of Single Market” was published and heralded the beginning of a whole new era for the chemical industry in terms of the legislation framing its activity and the roles attributed to different stakeholders. The current legislation is considered to have set a whole new paradigm in the management and orientation of chemical firms and its main features involve:

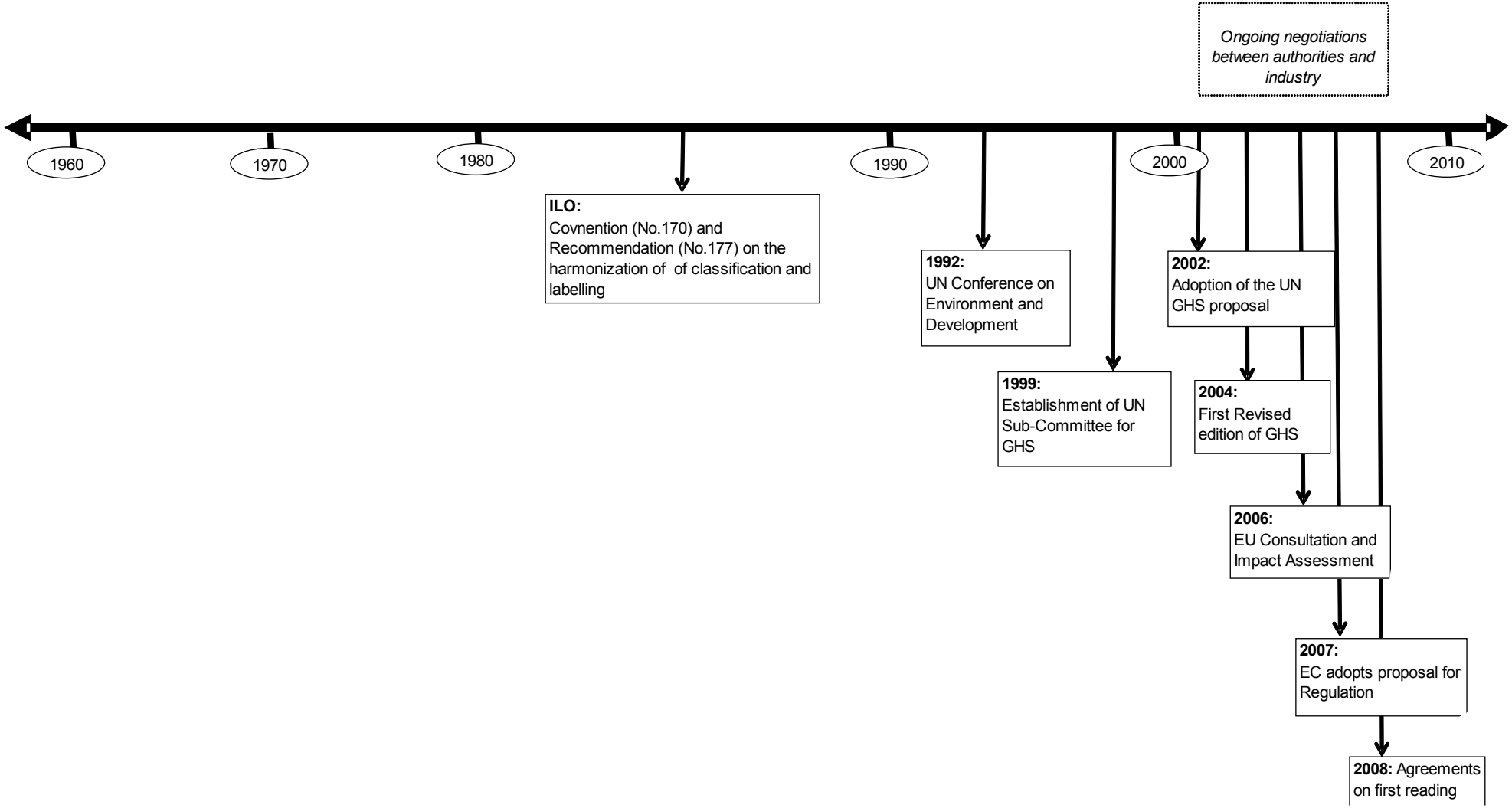
- a single system for existing and new substances;
- a duty of care for all manufacturers, importers and downstream users of chemicals;
- shift of responsibility/ workload from the authorities to the industry;
- shift of onus of proof from the authorities to the industry;
- authorization system of substances of “very high concern”;
- strict deadlines (Scailteur, 2001),
- safe use of chemicals across the supply chain.

The figure below presents the legislative background of REACH.


Concerns about chemicals
Continuous amendments of DSD (due to new knowledge)
Rising concerns about existing and new substances
Existing substances and preparations in focus and action towards changing the legislation
Negotiations and Formulation of REACH
Ongoing efforts for successful implementation
1960
1970
1980
1990
2000
2010
1967: Dangerous Substances Directive (DSD)
1976: Restrictions on Marketing and Use Directive
1981: Amendment of DSD establishes notification system for new substances
1993: Existing Substances Regulation, prioritization of 141 substances
1998: Initiation of process to change the legislation
1999: Dangerous Preparations Directive (DPD)
2001: White Paper on future EU policy on chemicals
2003: Proposals by DGs (Enterprise and Environment) and consultations
2006: REACH Regulation is adopted
2007: Regulation comes into force and the Agency is established

ANNEX 4: Globally Harmonized System for classification and labeling (GHS)

The Globally Harmonized System for Classification and Labeling (GHS) (COM (2007) 355) deals more with information dissemination rather than the properties of chemical products and aims at a common basis for the characterization of chemical substances with regards to their hazardous properties. The aim of the proposed regulation is to enable judgment on substances and/or mixtures with respect to their hazardous properties, provide hazardous chemicals with appropriate labeling and information on safety measures, reduce the need for testing and evaluation of chemicals and facilitate international trade. GHS was developed to overcome inconsistencies in classification and hazard communication at international level (RPA, 2006). The proposed system presents similarities as well as differences to the existing EU system; differences refer mainly to criteria, additional substances and hazards to be considered, evaluation of mixtures, concentration limits and some symbol changes. The harmonization of systems is not considered as a novel idea since other harmonization efforts were already in place. GHS targets not only the consolidation of national and continental differences in semantics, but also seeks to provide a common basis for classification and hazard communication for all audiences along the supply chain (i.e. workers, transporters, emergency responders, consumers, etc.). The figure below presents the legislative background of REACH.


Ongoing negotiations between authorities and industry
1960
1970
1980
1990
2000
2010
ILO:
Covnention (No.170) and Recommendation (No.177) on the harmonization of of classification and labelling
1992:
UN Conference on Environment and Development
1999:
Establishment of UN Sub-Committee for GHS
2002:
Adoption of the UN GHS proposal
2004:
First Revised edition of GHS
2006:
EU Consultation and Impact Assessment
2007:
EC adopts proposal for Regulation
2008: Agreements on first reading