# The Impact of Regulation on Innovation

*Compendium of Evidence on the Effectiveness of Innovation Policy Intervention*

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*The compendium is organised around 20 innovation policy topics categorised primarily according to their policy objectives. Currently, a number of the reports are available.*

*All reports are available at http://www.innovation-policy.org.uk. Also at this location is an online strategic intelligence tool with an extensive list of references that present evidence for the effectiveness of each particular innovation policy objective. Summaries and download links are provided for key references. These can also be reached by clicking in the references in this document.*

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## Executive Summary

Regulatory framework conditions have been identified as important factors influencing the innovation activities of companies, industries and whole economies. However, in the growing body of empirical based literature, the impacts of regulation have been assessed as rather ambivalent for innovation in general, often depending on the different types of innovation. Different types of regulations generate various impacts on innovation, and even a single specific regulation can influence innovation in various ways differentiating between innovation input, i.e. research and development, and output, e.g. incremental or radical innovations, often depending on how it is implemented.

The endogenous growth approach developed by Carlin and Soskice (2006), which determines endogenously the rate of technological progress and therefore innovation, allows a conceptual analysis of the influence of different types of regulation on innovation. In general, the negative effect of compliance costs, which are most relevant in the short run, is compared with the more dynamic effect of regulations generating additional incentives for innovative activities. Based on this approach, we analyse the impacts of different specific regulations on innovation assuming that all types of regulation promote the diffusion of innovation in general.

We differentiate between economic, social and institutional regulations following the OECD taxonomy of regulations. Existing empirical analyses are surveyed, which are characterised by rather heterogeneous methodological approaches, data bases and results.

If we examine the implications on the direction of innovation activities, economic regulations try to keep a high level of competitive pressure, which forces companies both to realise process innovations in order to succeed in price competition and to successfully introduce new products and services into the market in order to escape from fierce competitive pressure. These general impacts can be observed in most of the existing studies, although the immediate specific impacts that foster innovation are difficult to identify. Besides the general studies, the overview of sector-specific studies on the impact of regulation on innovations complements the picture by confirming that the impacts are both sector specific and also company and innovation type specific.

Social regulations mainly addressing negative external effects have strong impacts on the direction of innovation activities towards the protection of the environment, the health and safety of citizens in general, but more specifically of consumers and workers. The majority of the studies examined focus on the innovation impacts of environmental regulations. Despite some early ambivalent results, most recent studies reveal mainly positive impacts. This is also due to the fact that environmental policies and the responsible regulatory bodies use regulation explicitly as one policy instrument to foster innovation in contrast to most other policies and regulating institutions.

Very few studies on selected institutional regulations provide evidence of stronger incentives for innovation activities, such as product liability towards safer innovative products and services. In addition, employment protection legislations may have in general a positive impact

depending on the type of innovation, whereas immigration laws do not show any influence yet.[1] More restrictive bankruptcy laws are negative for innovation, because they divert activities and investments away from risky towards less innovative engagements. Finally, only the innovation impacts of intellectual property rights (IPRs) regimes as a very generic form of regulation have been investigated in several studies, which confirm the expected and intended general positive impacts. However, some recent studies raise doubts about the innovation incentivising impacts of IPRs, which are increasingly used for the achievement of companies' strategic objectives rather than having innovation as a top priority.

In summary, the numerous empirical studies on the impact of different types of regulation on innovation present a rather heterogeneous picture both regarding the type of regulation, the sectors, the companies and the time horizon of the impacts. The studies also show differences between short and long term impacts. The short term impacts of regulations are often negative for innovation in contrast to the long term implications by forcing or encouraging their adoption; and accelerating the uptake of innovations and their spillover benefits. Interestingly, it should be noted that the impacts are not time invariant, i.e. earlier studies find slightly more negative impacts, whereas more recent investigations tend to reveal more positive implications especially in relation to environmental regulations. Furthermore, it has to be noted that most quantitative studies about the impact of regulations are not able to distinguish between the influence of changes in the legislation (on innovation activities) and of their enforcement and the related compliance of companies. Finally, the development of an "innovation culture" within regulatory bodies certainly promotes the positive innovation impact of regulations. However, this aspect has not been analysed yet.

Research gaps still exist in the development of appropriate indicators of the regulatory framework. Furthermore, the processes within companies to react to regulations deserve more attention to understand the rather heterogeneous impacts on innovations. Finally, regulations are per se not only exogenous to companies, but often there is close interaction between regulators and the regulated companies, which should further explain some of the existing ambivalence.

Based on the general insights from the conceptual approach, the empirical analyses, but also the gaps identified, the following proposals for more innovation-friendly and innovation targeting regulatory policies can be derived:

- Strengthen the focus on innovation in regulatory policy.
- Increase the quality of the regulatory framework regarding innovation.
- Improve the implementation of regulations to foster innovation.
- Include innovation in ex ante and ex post regulatory impact assessments.
- Optimise the frequency and timing of reviewing existing regulations.
- Coordinate the policies of all relevant regulatory bodies to foster innovation.
- Move innovation into the centre of public policies in general and in the set of objectives and the general culture of regulatory bodies in particular.
- Integrate regulation in the research on innovation systems.

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[1] More details on labour regulations can be found in the NESTA Compendium report by Barbra Jones (2012): Innovation and Human Resources: Migration Policies and Employment Protection Policies; London/Manchester.

# 1 Introduction

Regulation, innovation and competitiveness in global markets have been discussed for several decades. Recently, policymakers have started to extend their focus towards the regulatory framework as a possible instrument for innovation policy, especially because many countries have little leeway to increase public spending in R&D and other innovation related activities after the global financial crises. Therefore, policies to improve the regulatory framework conditions relevant for innovation or even setting regulation with the explicit objective to promote innovation are becoming more important.

Classifying the numerous types of regulations, one can distinguish three types. First, there is a - rather limited – number of regulations which is immediately dedicated to promote innovation. The most relevant example is the regime of intellectual property rights, especially patents, and a few specific market regulations such as those recently promoted within the Lead Market Initiative by the European Commission. Secondly, there is the majority of regulations which try to achieve other specific objectives, but not to promote innovation per se. In order to realise the challenging objectives, like protecting health, safety or the environment, companies often cannot comply to the requirements of these regulations with slight modifications of their existing product assortment or their production processes, but are required to develop at least incremental or even radical new solutions, i.e. product or process innovations. Rules to shape market conditions in order to assure a certain level of competition belong to this second type of regulations. In a competitive market environment, companies are required to provide new innovative solutions. Finally, there is the remaining variety of regulations, which influence companies' strategies and activities, but not necessarily in a positive sense their innovations activities. In this last category, especially the regulatory burden on innovation is more relevant leading to less innovation in general.

Despite the variety of regulations and their numerous impacts on innovation, only recently some progress has been made to understand the effect of regulation on the ability of companies to innovate. Meanwhile some comprehensive studies have been conducted in addition to the great amount of anecdotal evidence. Some in-depth analyses provide insights that allow a further differentiation reflecting the heterogeneous impacts of different types of innovation. Nevertheless, in total, these studies still provide no clear picture of whether the negative impacts of regulation outweigh the positive effects.

There are a range of dimensions that shape the way regulations impact upon innovation activities of firms. First, the investigations of the impacts of regulations have to take sector specificities into account and have to address sector-specific regulations. *Second*, regulations have different kinds of impact for different types of companies. In general, with increasing size, companies have relatively less difficulties with regulatory compliance. Less clear is the influence of firm age. On the one hand, young companies trying to enter new markets or just having entered existing markets have less experience with the requirements set by regulatory bodies, on the other hand they have more flexibility to react to upcoming regulations. In addition, the position of companies in relation to the existing technological frontiers is another distinction between companies for structuring the impacts of regulations. *Third*, the regulation impacts on companies can be differentiated between short and long term impacts. In the short term, the required regulatory compliance creates a burden for most companies, which might be negative for innovation. In the long term, the innovation impact is very regulation specific. *Finally*, the

degree of flexibility in the implementation of regulations has a strong influence on companies' inclination towards radical or incremental innovations. In summary, the analysis of the impacts of regulations on innovation should take all these dimensions into account.

Since the impacts of numerous regulations are related to various other policy instruments covered in the NESTA Compendium and this survey cannot address all areas of regulation, we will not cover a range of areas: Public procures have to follow numerous regulations. However, this is dealt with in the report on public procurement. Tax law can also be perceived as a form of regulation. Nevertheless, this is addressed in the report of financial incentives. Further, labour regulation and its relation to innovation is focus of a separate report. In addition, for numerous regulations, like rules on urban planning, the literature survey has not provided any significant evidence. Consequently, these regulations are not covered in the overview. Finally, complementary to regulatory schemes, self- and co-regulatory rules are important for innovation. Especially, the influence of standardisation and standards will be treated in a separate report.

The objective of this contribution is to provide a comprehensive overview on the impacts of regulation on innovation taking into account the variety of regulations (see Table 1), their ambivalent and often context specific impacts and their dynamic relationship. Consequently, chapter 2 starts with a theoretical concept reflecting the dynamic causalities between regulation and innovation, which allows us to distinguish between different types of regulations and their general positive and negative impacts on innovation. Based on this conceptual framework, we discuss both the theoretical underpinning of impacts and the existing empirical evidence of different types of regulation on innovation including an overview of sector-specific regulations in subsections of chapter 2. We conclude with a discussion of the implications derived from the empirical findings.

**Table 1: Types of regulations covered in the report**

| **Economic regulations** |
|---|
| Competition enhancing and securing regulation |
| Antitrust regulation |
| Merger & acquisitions |
| Market entry regulation |
| Price regulation |
| Regulation of natural monopolies and public enterprises |
| |
| **Social regulations** |
| Environmental protection |
| Workers health and safety protection |
| Product and consumer safety |
| |
| **Institutional regulations** |
| Liability law |
| Employment protection legislation |
| Immigration laws |
| Bankruptcy laws |
| Intellectual property rights |

Although there is no real tradition of empirical studies on the influence of regulation on innovation, there are several studies, which assess the influence of the different types of regulations on innovation. The most important studies on economic regulations will be presented in the following sections. The literature search was based on Internet searches (incl. Google Scholar) and the Web of Sciences, i.e. unpublished documents have not been included, focusing on very recent studies (see in contrast the historical-overview in BERR (2008)). More than 100 sources have been screened and integrated. The focus is on peer-reviewed articles, but these are complemented by working papers of well known institutions, but therefore a certain quality level can be assumed. Finally, the referenced studies are mainly investigating regulations focusing on the United States and Europe or more generally on the OECD countries.

## 2 Conceptual Background

There are various definitions of regulation. However, we will stick to the very generic definition published by the OECD (1997), in which regulation refers to the implementation of rules by public authorities and governmental bodies to influence market activity and the behaviour of private actors in the economy. Such intervention in the market is justified to maximise collective welfare, including reaching some distributive goals. Economic literature (recently Stewart 2010) and OECD (1997) research distinguishes between economic, social and institutional regulations, which we use to structure our literature survey.

There are various approaches to illustrate the impact of regulation on innovation. Stewart (2010) distinguishes between compliance innovation and circumventive innovation. Circumventive innovation can be realised when the scope of the regulation is rather narrow and an innovation allows companies to escape the exposure of the regulation. Compliance innovations have to be achieved when the coverage of the regulation is rather broad and the resulting product or process innovations remain consequently within the scope of the regulation.

We follow the line of argument provided by Carlin and Soskice (2006), which differentiates clearly between the incentive impact and the compliance cost of regulations. They determine an equilibrium rate of technological progress and consequently innovation endogenously. Starting from the Solow growth model, a negative relationship between the rate of labour productivity enhancing technological progress or innovation – analogously to an increasing population or labour force – and the equilibrium capital intensity can be derived. This relation is called the Solow relation. In contrast, the Schumpeter relation assumes that with increasing capital intensity more resources are available for investments in research and development, which allows to foster innovation.

If regulation is introduced into this equilibrium scheme, two effects have to be considered. First, the compliance cost of regulations reduces – in a manner similar to that of a tax – the available resources for investment in research and development. Consequently, we expect a lower capital intensity and a reduced level of technical progress and innovation (Crafts 2006). This negative impact for the whole industry or economy is likely in the short run. However, in the long run "smart" regulation allowing flexible solutions (Stewart 2010) may reduce the regulatory burden and more resources will be available for research and development. Second, regulation changes the incentives for investments in R&D. Some regulatory schemes, such as the special case of patent protection, may create additional incentives to invest in R&D (Carlin, Soskice 2006) whereas others such as price restrictions and product market regulation, may reduce incentives for innovators (Crafts 2006).

Consequently, the net impact of regulation on innovation depends on the extent of the compliance cost on the one hand and the incentive effect on the other hand. We expect a positive impact on innovation, if compliance costs are low or even zero and the incentives are positive and a negative impact especially in case of high compliance cost and low or even negative innovation incentives.

The theoretical model shows that it is necessary to differentiate between specific types of regulation for an empirical assessment of their impact on innovation. However, in addition to the ambivalence of regulation on the creation of innovation, regulation can speed up the

diffusion of innovations by forcing or encouraging their adoption; and accelerating the uptake of innovations is a way of maximising the spillover benefits. However, this diffusion impact of regulations, which is important in reality, is not covered by this conceptual model.

## 2.1 The impact of economic regulation on innovation

Among economic regulations, we differentiate and focus on competition policies, including Antitrust regulations, rules for mergers and acquisitions, market entry regulations, price regulation and the regulation of natural monopolies and public utilities. At first, we present briefly the theoretical and conceptual arguments of the different types of regulation and the empirical evidence. Although most of the regulations aim to protect competition and even to enhance competitive pressure, we distinguish between the different subcategories to structure the arguments in a more comprehensive way.

### 2.1.1 Regulation of Competition

In general, policies designed to enhance competition increase the incentives for companies to invest in innovation activities in order to escape – at least partly– from fierce competition. However, if competition becomes so intense that imitation activities are more attractive than innovation activities, because the rents for innovators are significantly reduced (e.g. Scotchmer 2004), the positive impact of competitive pressure on innovation may change into a negative one according to the proposed inverse U-shape between competition and innovation intensity (Aghion et al. 2005). Recently, Amable et al. (2009) contested this U-shape by allowing different innovation strategies of the leading companies, which makes more innovation at a higher level of competition especially likely outcome of fierce rivalry in hightechnology markets . In addition, if competition regulations, such as Antitrust regulation and rules for merger and acquisitions, restrict the cooperation between companies also in research and development, such innovation activities may not be initiated and possible efficiency gains cannot be exploited.

Starting with an analysis of some empirical studies on the impact of economic regulations on innovation, Bassanini and Ernst (2002) find a negative correlation between the intensity of product market regulations and the intensity of research and development expenditure in OECD countries, which was recently confirmed for the Member States of the EU by Barbosa and Faria (2011), focusing on the share of innovators based on data of the Community Innovation Survey coordinated by Eurostat. Swann (2005) examines a significant number of British companies also surveyed within the Community Innovation Survey and shows that the content of regulations is an important source for innovators (see also Aschhoff and Sofka (2009) for Germany), but also a severe obstacle for the success of innovation activities. In a study focusing on the telecommunication sector in the United States, Prieger (2002) confirms a negative influence of stricter regulation on service innovations proposed by telecommunications providers to the regulatory authorities. Besides these studies, there is a tradition of research on the influence of competition and antitrust regulation on innovation. Koch et al. (2004) detect in a panel study a positive impact of antitrust regulation on the R&D intensity in former G7 countries. This is in line with Geroski (1991) who finds a positive correlation between competition intensity and innovation activities measured by patents in British industry sectors. Aghion et al. (2005) continue this research tradition and find an inverse U-shaped relation between competition intensity and patents as innovation indicators in the United Kingdom. Recently, Amable et al. (2009) developed a new extended conceptual model by taking into account the concept of technological frontier and found empirical evidence that innovation in industries close to the

technological frontier is less negatively influenced by regulations, which questions the previously postulated and empirically confirmed inverse U-shape between competition intensity and innovation.

Antitrust regulation is challenged in markets where innovation is a critical dimension of competition. Traditionally, economic scholars are quite critical against a monopoly position of companies derived from their success mostly based on radical innovations. Courts have also reacted quite drastically against such big players, like Microsoft in the past and Google, Apple and others more recently. Manne and Wright (2010) argue that false decisions restricting this type of company may harm both innovative companies in general and the economy as a whole. To underline their argument, they present a list of case studies, also covering Microsoft, which do not provide clear evidence that antitrust measures can been justified, because the costs to society are higher due to the innovation deterring impacts (see also Spulber 2008a, b). The same line of reasoning is recently presented in the case of Google (Manne and Wright 2011). The challenge of the impact of antitrust regulation on innovation is that these cases are quite specific, which allows neither a general conclusion on how to decide the conflicts in court nor a general assessment of the impact of antitrust regulation on innovation.

A new impact of regulations focusing on mergers and acquisitions on innovation has been proposed and analysed by Chemmanur and Tian (2012). They study the relation between so called antitakeover provisions and innovation. On the one hand, they argue that in the long run these provision foster innovation by protecting managers from short-term pressures, e.g. the equity markets. This insulation allows them to focus on long-term projects to promote companies' value. On the other hand, the antitakeover provisions reduce the disciplining pressure of the market for corporate control on managers and therefore their efforts on innovation. Chemmanur and Tian (2012) find in their empirical analysis based on more than 3000 US companies that firms applying a larger number of such antitakeover provisions are more innovative, especially when such a protection is more needed, because innovations are more difficult to achieve in the short term. For less innovative firms, antitakeover provisions are negative for the development of their firm value. Sapra et al. (2011) develop a theory of the effects of external corporate governance mechanisms such as takeover pressure and internal mechanisms such as compensation contracts and monitoring intensity on innovation by firms. From their model they derive the hypotheses that innovation varies in a U-shaped manner with takeover pressure. For US companies under the regime of state level antitakeover laws, they find strong empirical support for their hypotheses using R&D and patents as measures of innovative activity. Their prediction of a U-shaped relation between innovation and takeover pressure suggests that innovation is fostered by either strong anti-takeover laws that significantly restrict takeovers or an unhindered market for corporate control. .

Deriving the overall implications for regulations to foster innovation, the findings by Chemmanur and Tian (2012) suggest that there is an additional company specific argument – in addition to securing sufficient competition – to consider in restricting takeovers especially of innovative companies requiring a long term commitment to innovation. However, the U-shaped relation between innovation and takeover pressure found by Sapra et al. (2011) does not allow us to derive a clear recommendation. Obviously, further research is needed to provide specific recommendations to regulators responsible for antitakeover laws.

### 2.1.2 Market Entry Regulations

Market entry regulation increases the hurdles for companies to enter a specific market. This may be positive for the incumbents, because it reduces the competitive pressure and allows them to invest more resources in risky innovation activities assuming a rather high level of competition intensity. However, market entry barriers make it very difficult for innovative companies to enter markets, which is negative for the overall innovative performance in these markets, especially if the competition intensity is still rather low.

Market entry regulations as such are not investigated, but market entry as such was recently analysed by Aghion et al. (2009). They find that there is a heterogeneous impact on the impact of firm entry on the innovation of incumbents across industries. Particularly, incumbents' productivity growth and patenting is positively correlated with lagged foreign firm entry in technologically advanced, but not in laggard industries. This result is explained by the argument that the threat of technologically advanced companies entering the markets spurs innovation incentives in sectors close to the technology frontier, where successful innovation allows incumbents to survive the threat. In laggard sectors, entry discourages innovation, because incumbents' expected rents are decreased from innovating.

### 2.1.3 Price Regulations

The impacts of price regulations on innovation depend crucially on their specific implementation. If price regulation results in companies' securing a certain minimum revenue or reducing their risk on the demand side, then the incentives to innovate increase, whereas the compliance cost are negligible. Price cap regulations have been analysed in many studies, especially in the telecommunication sectors. However, the only impact vaguely connected to innovation, which has been investigated, is service quality.

### 2.1.4 Regulations of Public Utilities

The regulation of natural monopolies and other public utilities has been a crucial issue over the past decades resulting in the liberalisation and privatisation of several originally publicly dominated markets. Under the regulatory framework in the 1960s and 1970s, monopolies and public utilities had no market oriented incentives to innovate. Therefore in the 1980s, the United States started to implement regulations to motivate them to increase their productivity and achieve innovations. However, these regulatory principles reduced the rents of the regulated firms which could be used for large R&D projects and other innovation activities. Therefore, an incentive dilemma emerged for some public utilities.

In particular, network-based services, such as telecommunications, water and energy supply, were regulated under the old principles of rate of return regulation or pricing at marginal costs. The rate of return regulation states that a monopoly should not achieve a profit higher than the average firm in the industry. Under marginal cost pricing, the monopoly was forced to price its products according to two-part tariffs (Ramsey-Pricing). These regulatory schemes were responsible for the low or biased technical progress towards capital intensive production (Averch, Johnson 1962) and resulted in little innovation in some regulated industries, such as telecommunication and energy. Based on the progress of the economics of information (Stiglitz 1975), appropriate incentive schemes were developed to overcome the information asymmetries between regulated companies and regulatory bodies. This led to the implementation of new regulatory measures based on the idea that there is a 'revelation-

incentives' dilemma that can be solved by a fine tuning via 'price cap' regulation. Price cap regulations are based on contracts between the regulator and the regulated firm, which require minimum quality and fixed maximum prices. If the regulated firm can realize some additional profits by productivity gains, incentives for innovation are created, whereas if the regulatory body wants to capture all revenues from productivity gains, the regulated firms have no incentive to innovate. The same is true if the regulatory framework implements competition, which allows multiple suppliers with inefficient cost structures. Consequently, they try to increase their market shares by price competition, which reduces their profits and hampers investment in R&D and innovation.

The empirical evidence of the impacts of regulations of public utilities or even monopolies is connected to their liberalisation. At first, the objective of these analyses was to develop instruments to achieve cost covering business models. Later, Averch and Johnson (1962) examined incentives schemes to increase the productivity of public utilities. In the 1990s the innovations of public utilities were triggered by the deregulation and liberalisation of former publicly owned or monopolised sectors. Various country studies (United States and Canada (OECD 1999a; OECD 1999b) and sector studies (OECD 1997) show that innovation significantly increased after the implementation of competition in markets such as telecommunication (see below), but also transport and mail services, recently supported by the findings of Amable et al. (2009), who find that increases in the number of companies in service markets triggered by deregulation have a positive influence on innovation measured by patent applications.

Table2: Incentive effects and compliance costs of economic regulations[2]

| Type of regulation | Compliance cost or negative incentive effects | Positive incentive effect | Empirical evidence |
|---|---|---|---|
| Competition enhancing and securing regulation | Reduces rents for innovators<br>Prohibits R&D cooperation | Increases and secures incentives to invest in innovation | Ambivalent |
| Antitrust regulation | Dominant (innovative) companies have limited incentives to invest further in R&D | Allows competitors to enter the market and put pressure on dominant companies | Only anecdotal evidence |
| Merger & acquisitions | M&A restrictions limit takeover pressure and incentive to innovate | M&A allows efficient takeover of innovative companies<br>M&A restrictions protect management from short term market pressures | Ambivalent (U-shape) |
| Market entry regulation | Prohibits market entry of probably innovative newcomers | Reduces competition for incumbents, e.g. for infant industries | Only indirect evidence of entry pushing innovation in technology advanced sectors |
| Price regulation | Price caps reduce innovation incentives | Minimum prices secure minimum turnovers and decrease risks; completely free prices allow monopoly pricing | Not available |
| Regulation of natural monopolies and public enterprises | High price pressure and low gains allow no investments into R&D in case of marginal cost pricing | Incentives to achieve progress in productivity in case of rate of return regulation | Positive in case of deregulation |

### 2.1.5 Empirical Evidence of the Impact of Sector-specific Regulations

In addition to the survey of studies not focusing on sector-specific regulations, we provide a complementary, but also partly overlapping overview of studies on the impact of especially sector-specific regulations on innovation. In this overview, we concentrate on those rather innovative sectors (following Stewart (2010) summarising U.S. studies), which are heavily regulated, because there is in general a higher interest to study the impact of regulation on innovation.

[2] Extension of Blind (2012).

#### 2.1.5.1 Chemical Industry

Due to its various risks the chemical sector is traditionally rather intensively regulated. Almost 30 years ago Ashford and Heaton (1983) conducted a detailed qualitative analysis of the impact of regulation, e.g. on toxic substances on innovation in the chemical industry. They differentiate the regulations into preapproval screening regulations and end-of-pipe regulations focusing existing products and processes. They find that the compliance uncertainty caused by premarket screening regulations tends to negatively impact innovation in small and young companies, while positively influencing innovation in larger, more established firms. They argue that young companies tend to introduce new products, which are then subject to the approval process, whereas larger companies are better able to cope with the compliance burden. In addition, they find evidence that premarket screening supports innovations, because more rigorous R&D is required to ensure that approval helps the companies themselves to gain more knowledge about potential applications of the product. Finally more stringent end-of-pipe regulations focusing on existing products and processes foster innovations, but also delay the development of the required technologies. Also focusing on the regulation of toxic substances finds a small negative effect on innovation, but also positive impacts on the recycling of material that was previously discharged into the environment.

Ollinger and Fernandez-Cornejo (1998) study the effect of environmental regulation on the innovation of pesticides and find that increasing regulatory costs decreased the number of pesticides brought to the market. Regulation encouraged firms to develop less toxic pesticides, however, the overall innovation of pesticides was reduced. Finally, Porter and van der Linde (1995) provide several anecdotal examples of environmental regulation stimulating innovation in the chemical industry leading to significant cost savings for the affected companies.

In a comparative study between the US, the EU and Japan, Fleischer et al. (2000) find that the EU system provides cost disadvantages for chemical companies interested in notifying new chemical entities. However, for large companies, market entry barriers may temporarily eliminate the adverse competitive effects of the EU notification system. In addition, the EU system provides a quasi-patent protection for the first notifying company. The protection in form of market entry barriers due to the regulation costs and to the quasi-patent status granted to the first notifier may temporarily help large corporations in the EU. However, small and medium-sized companies cannot afford, in general, to develop and notify new chemical substances. Fleischer et al. (2000) relate these framework conditions with the rather low innovation performance of European companies compared with US and Japanese companies without applying rigorous econometric methodologies. Very recently, Rubim de Pinho Accioli Doria (2010) investigated the impact of regulatory stringency on innovation in the chemical industry by analyzing the evolution of innovative activity in highly regulated technological areas in the European Union from 1976 to 2003. Overall, regulatory stringency influenced positively patenting activity. However, large companies experienced a negative impact on their patenting activity. Consequently, the concentration of innovative activity in highly regulated technological areas has been reduced. Major changes occurred in areas in which the largest number of regulatory restrictions was imposed. In addition, Rubin de Pinho Accioli Doria finds an overall increase in innovations associated with new processes and formulations, indicating increased incremental innovation and a shift from patenting in regulated to non-regulated areas. In addition, patenting activity increased in areas that did not depend on novel chemical substances or did not have an opportunity to innovate in non-regulated uses. By contrast, there was a sharp fall in patent applications in areas in which these conditions did not exist. Obviously, “new”

technologies benefit from regulatory stringency, while "old" technologies are discouraged. Moreover, this thesis shows that the Porter hypothesis is supported by evidence from the chemical industry. Yet, this occurs not because firms innovate under more stringent regulation, but because it stimulates new entrants in the market of innovation.

#### 2.1.5.2 Pharmaceutical and Biotechnology Industry

The pharmaceutical industry has traditionally been heavily regulated. This regulatory scheme has been applied partly also to the emerging biotechnology industry. Consequently, there are – compared to other sectors – numerous studies, which analyse the impact of regulation on innovation.

Using regression analysis Hauptman and Roberts (1987) find that the increased stringency of an amended FDA (Federal Drug Association) regulation on medical devices and the resulting compliance uncertainty reduced in the short term innovations especially of advanced technology products, but in the long term companies adapted their processes to innovate effectively in the more stringent regulatory environment. Wrubel et al. (1997) also observe this rebound effect in a study on the impact of regulation focusing on genetically engineered microorganisms (GEMs), not because the companies adapted to the new framework conditions, but because the regulators clarified and streamlined the regulation and its implementation.

For the pharmaceutical industry Grabowski and Vernon (1977) and Grabowski et al. (1978) observe that increased stringency of regulations and compliance uncertainty due to regulatory delay decreases the market introduction of new drugs, because innovation activities are concentrated in larger firms less burdened by the compliance costs of regulation (see also Thomas 1990). This concentration process reduced competition and consequently innovation in the US pharmaceutical industry. Recently, Vernon et al. (2009) provided complementary results by showing that a 10% decrease of approval times of new drugs by the FDA increased the R&D spending of pharmaceutical companies by 1% to 2%.

Focusing on the information provided by regulation Katz (2007) and Eisenberg (2007) postulate that regulation that promotes information or reduces information asymmetry in the drug market can stimulate innovation by increasing the expected returns of successful innovation.

Besides the regulation responsible for organizing the market access of drugs, the pharmaceutical sector has also to follow the price regimes of drugs. Vernon (2003, 2005), Vernon et al. (2006) and Golec and Vernon (2010) find empirical evidence that drug price controls reduce the R&D intensity and the market introduction of new drugs by pharmaceutical companies. Finally, Golec et al. (2005) show that policy uncertainty related to price controls can reduce R&D spending well before the regulation is in effect, but also change the nature of innovation from developing expensive breakthrough drugs to cheaper patentable innovations that do not require heavy R&D investment.

Besides these broad studies about the impacts of regulation on innovation in the pharmaceutical and biotechnology sector, the very case-specific Orphan drug regulation has to be mentioned. The Orphan drug regulation focuses on rare diseases and restricts the market to a single pharmaceutical company investing R&D to find new chemical entities as the basis for new drugs. This kind of infant industry regulation has been investigated by Reaves (2003), who finds a positive impact on pharmaceutical innovations.

#### 2.1.5.3 Automobile Industry

Another important and heavily regulated sector is the automotive industry. Atkinson and Garner (1987) study the impact of the flexible performance-standards-based regulatory regimes that were implemented in the 1960s and 1970s, including the introduction of stringent emissions standards, e.g. the Clean Air Act Amendments. They argue that these disruptive environmental standards brought the American auto industry more in line with customer demand for lighter, more fuel-efficient automobiles, helping it compete with already-efficient Japanese vehicle. Consequently, the environmental performance standards reduced not only emissions in the short term, but those same innovations also allowed U.S. automakers to retain market share. However, they admit that the regulations were implemented when the car market was experiencing a significant shift in customer demand combined with increased competiveness especially due to globalization. In addition, Gerard and Lave (2005) study the same case and find mixed results, because after the heavy R&D investment in converter technology both industry R&D intensity and patenting dropped sharply.

Goldberg (1998) analyses the impact of the corporate average fuel economy (CAFE) standards and finds that they were successful at spurring environmental innovations. She tests whether the downward pressure on fuel consumption due to the standards was offset by a "utilization" effect, whereby consumers increase the mileage driven in fuel efficient cars; and a "compositional" effect, in which consumers switch to less fuel efficient models. She finds no evidence of the former and little evidence of the latter, suggesting that the environmental objective has been achieved.

Lee et al. (2004) analyse regulatory measures related to emission control and safety technologies in the U.S. Automobile Industry and find in a longitudinal study of patenting that these "technology-forcing" standards have stimulated innovations. In a later version Lee et al. (2007) admit that the regulations were only effective in driving innovation in the early phase of technological change. Furthermore, Smith and Crotty (2008) find evidence that the EU End of Life Vehicles Directive (ELVD) has driven regulation effectively diverting innovative capacity into short-term, incremental technological trajectories rather than into more radical, sustainable direction product innovation.

Finally, Pilkington and Dyerson (2006) examine the development of electric vehicle technologies and find that while emissions regulations effectively promoted incremental innovation in internal combustion engine vehicles, they have not stimulated the radical innovations required for the successful commercialization of electric vehicles.

#### 2.1.5.4 Telecommunications

Following the deregulation of telecommunication sectors, several studies focused on the impact of regulations in more competitive markets. Prieger (2002) finds that in a period of decreased stringency in the regulation of telecommunications relevant for the introduction of a new telephone service connected with a reduced compliance uncertainty the number of innovations increased significantly. In a similar study, Prieger (2007) investigates the effect of compliance uncertainty and discovers that reduced regulatory delay increased innovation. Ai and Sappington (2002) study the impact of the change in the regulation of telecommunication companies from rate-of-return regulation to more flexible incentive-based regulations and find that it resulted in an increase in innovation, e.g. increased network modernization and process improvements, measured by lower operating costs, as proposed and predicted by Averch and

Johnson (1962). Schmalensee and Rholfs (1992) and Tardiff and Taylor (1993) find the same impact by using total factor productivity as a measure of innovation. In contrast, Ying and Shin (1993) observe increasing service costs under incentive regulation, whereas Kridel et al. (1996) cannot detect a decline in service quality. In contrast, Kahn et al. (1999) argue that the deregulation of the telecommunication sector to promote competition among telecommunications carriers reduced the opportunities to innovate. The less flexible rate-of-return system actually offered greater incentives for innovation, because carriers could claim their R&D expenditures as capital costs allowed them to undertake large-scale and risky R&D activities more likely to generate radical innovations. However, their propositions are not backed by empirical evidence.

Recently, studies like Ehrlich et al. (2010) investigate the influence of regulation on platforms, e.g. in the area of wireless communication, or on two sided markets (Rysman 2009) on innovation. In general, they propose regulations securing network or technology neutrality. However, empirical studies based on sound data are not yet available, but will become more relevant due to the increasing relevance of networks, especially the Internet, for innovation (see Blind (2011) for an overview).

#### 2.1.5.5 Finance and Banking

There are few empirical studies on the impact of regulation on innovation in the financial sector (Jackson 2007). However, financial innovations are neither always helpful nor always threatening (Lumpkin 2009). However, they have the potential to provide a more efficient allocation of financial resources and thereby a higher level of capital productivity, but also promote capital-intensive innovations in other sectors. Many financial innovations have improved the allocation efficiency related to financial resources. However, the recent financial crisis was triggered by financial innovations, which promoted delinquencies, bankruptcies or other problems. Since innovation should be possible and encouraged in the financial sector, an appropriate balance between preserving the stability of the system and allowing financial institutions and markets to innovate should be found (see White (2000)) for on overview on various regulations in the financial sector).

Baer and Pavel (1988) find that increased stringency of bank regulation, e.g. capital taxes and reserve requirements, promotes financial innovations, e.g. Eurodollar deposits. Based on a qualitative analysis, Silber (1983) observes that less than 30 percent of financial innovations were induced by regulation. Jagtiani et al. (1995) find no influence of increased stringency of bank capital requirements on innovation. Finally, Warren (2008) proposes that the inflexibility of some regulations hinders those innovations that are most beneficial to consumers e.g. new ways of informing consumers, while failing to regulate risky innovations, e.g. negative amortization.

#### 2.1.5.6 Healthcare

Stewart (2010) notes that there has been little empirical research on the impact of regulation on innovation in health care, which is also supported by Koornneef (2010). However, many of the innovative products employed by service industries, like healthcare, are produced by other industries, such as manufacturing, pharmaceuticals, and biotechnology. To close the gap at least partly, Walshe and Shortell (2004) conducted a mostly interview-based study on the impact of regulation on healthcare organizations' performance. They find that regulation of healthcare organizations had a generally positive effect on continuously improved processes (see on

related quality improvements Leatherman and Sutherland (2006)), but a generally negative effect on product or service innovation.

#### 2.1.5.7 Summary of evidence from sector-specific regulations

The overview of studies analyzing the impacts of sector-specific regulations confirms the expected heterogeneous picture. Still, some general conclusions can be derived. Uncertainty and delays related to the development and the implementation of regulations are disincentives for investments in innovation, whereas companies are more innovative under flexible and incentive-based regulations. The stringency of regulations is ambivalent for innovation. The more stringent regulations the more likely will be radical innovations, whereas less stringent requirements induce more incremental innovations.

Overall, for most sectors the evidence on the impact of regulations on innovation is rather limited and does not allow the derivation of robust general conclusions. And even in the more intensively investigated sectors, there is still an ambivalence of insights due to different methodological approaches applied or data used.

## 2.2 The impact of social regulation on innovation

### 2.2.1 Theory

The impact of social regulations, a term defined by the OECD (1997), on innovation has recently been more frequently analyzed. Most of the existing literature on social regulations and their impact on innovation focuses on the analysis of the impact of environmental regulation caused by the increasing importance of environmental issues (Kemp 1998). In addition, new environmental regulations have resulted in the scrapping of existing machinery and equipment and enabled new entrants to introduce new production techniques in industry. Therefore, we focus this chapter on the numerous studies dealing with the impacts of environmental regulations.

Environmental regulations have caused the emergence of new industries, such as the 'environmental industry', and of new products with fewer or almost no negative impacts on the environment. Consequently, environmental regulations drive the industry explicitly towards the development and implementation of innovative technologies which protect the environment or produce at least less environmental damage. For example, Kemp (1998) proposes to use regulation as a moderator of technological change, i.e. regulations may change the direction of technological change into innovations with less negative impact on the environment. The innovation triggering effect of environmental regulations was perceived by Michael Porter in his famous Porter hypothesis stating that ambitious environmental regulations may be challenging for the national industry at the very beginning, but help to improve international competitiveness and to increase exports of the developed environmental technologies (Porter, van der Linde, 1995).

The counter-hypothesis postulates that environmental regulations restrict firms in their innovative activities and cause additional costs, at least in the short run, which have a negative impact on their competitiveness and consequently also on their capability to innovate. It is consensus that the regulation of end-of-pipe technologies has these negative effects, whereas the regulation of integrated environmental protection may be ambivalent for innovation.

In sectors with strong ethical considerations and a high importance of externalities or better an inherent need for safety given the risk to human life and health, as in the health sector, the activities and strategies of the actors involved are so restricted by regulations, that the link between regulation and innovation is obvious and close. On the one hand, safety regulations may prohibit innovations, if public authorities forbid potentially risky products and therefore likely radical innovations. On the other hand, these regulations increase the acceptance of new products and services among consumers, since they can rely on some minimum product safety. However, the health sector is especially affected by various other means of intervention (Day, Frisvold 1993). Consequently, the perspective has to be broadened from the single regulation to the institutions that surround the regulatory framework.

### 2.2.2 Empirical Evidence

In this section, we present the results of studies focusing on regulations or more precisely environmental regulations including energy related issues and their impact on innovation. Following the seminal contribution of Porter and van der Linde (1995), several further contributions (e.g. Jaffe et al. 1995; Jaffe, Palmer 1997; Shadbegian, Gray 2003) produce ambivalent results regarding the influence of regulation on the development of new environmental technologies. For example, Jaffe and Palmer find no relationship between environmental compliance costs and patent counts as indicator for innovation, they do find a statistically significant relationship between compliance costs and R&D expenditures. Furthermore, the authors cannot differentiate whether the regulation has caused firms to "wake up and think in new and creative ways about their products and processes," or whether firms are increasing R&D to comply with regulation at the expense of other, potentially more profitable R&D investments (Jaffe and Palmer 1997, p. 18).

In the consumer appliance industry, Newell et al. (1999) find that the performance standards established by the National Appliance Energy Conservation Act (NAECA) of 1987 on the energy efficiency of room air conditioners, central air conditions and gas water heaters improved the energy efficiency of room air conditioners and gas water heaters by about 2 percent per year faster than they otherwise would have. Norberg-Bohm and Rossi (1998) find that relevant water quality standards led mostly to incremental innovations in the pulp and paper industry, because radical innovators faced resource constraints.

Cohen (1979) and Marcus (1988) analyse the effect of regulation on innovation in the nuclear power industry. Marcus finds that regulations affected plants differently depending upon their prior safety records, i.e. the regulators take a less flexible approach to plants that had a poor safety record, while it took a more flexible approach to those with good safety records. Cohen (1979) reviews power plant licensing procedures and finds that they negatively impact market innovation through compliance uncertainty due to regulatory delay.

Lyon (1995) analyses the impact caused by a specific regulation, which assesses whether a utility's investment was "used and useful" and is a cost-effective source of power, from which the regulator determines whether the utility's investment should be disallowed. He finds that these reviews can cause a utility to forgo investing in risky innovation and instead utilize more costly conventional technologies. Furthermore, utilities may cease making technological investments at all and instead switch to purchasing power from third-party producers.

Sickles and Streitwieser (1991) investigate gas price controls and find that both the technical efficiency and the productivity of gas transmission firms fell, which is indicative of a diminishing innovative activity. Bellas (1998) finds evidence that the moving target of continuously revised regulations is not conducive to innovation in the energy industry. Based on these insights Lange and Bellas (2005) investigate the system of tradable permits and find more flexible incentives-based regulation to be more effective to spur innovation than the previous command-and-control regulatory regime (see also Majumdar and Marcus 2001). In contrast to Lange and Bellas (2005), Popp (2002) uses patent counts and finds a decreased level of innovation following another incentives-based regulation of a system of tradable permits. In a more qualitative approach, Taylor et al. (2005) find that government regulation precipitated by policy uncertainty can stimulate market innovation. Finally, contrary to Popp (2002), they find that the incentive-based regulations did not lead to more innovation than the prior regime of performance standards, because the incentive-based system simply came too late in the rather mature technology phase of the scrubber technology.

Lanjouw and Mody (1996) examine general trends of environmental innovation in response to the increasing environmental regulations in the United States, Germany, and Japan. They find that there is a correlation between regulatory compliance costs (as a proxy for stringency) and environmental patenting. Nameroff et al. (2004) look at patents on chemical products and processes to reduce or eliminate the use and generation of hazardous substances across all sectors in the United States. They find that an increase in the ratio of those chemistry patents to other chemistry patents is correlated with an increase in environmental regulation.

Finally, Popp (2006) extends the analysis of the impacts of regulation on innovation to a cross-country perspective and finds on the one hand that more stringent U.S. emissions standards relevant for electric utilities resulted in greater innovation in the United States, but had no effect on innovation in Japan and Germany. On the other hand U.S. firms innovate in response to domestic regulations, but not foreign regulations. Recently, Johnstone et al. (2010) examined the effect of various economic regulations on innovations of renewable energy technologies in OECD countries, and find that the effect of different regulatory regimes, including public R&D support, investment incentives, tax incentives, voluntary programs, quantity obligations, and tradable permits, varies across energy sources. Although, all the different types of regulation have a positive effect on the innovation of all energy sources, taking all instruments together they find that only tax incentives, quantity obligations, and tradable certificates have a positive effect on renewable energy innovation overall. Based on separate regressions, tax incentives stimulated innovation for a most renewable energy sources.

However, besides the briefly described studies, further studies (Hart und Ahuja (1996), Pickman (1998), Brunnermeier and Cohen (2003), Popp et al. (2007), Lanoie et al. (2008), and those listed in the survey by Gonzalez (2009) generally find, at least in the long run (supported by Blind (2012)), positive impacts of environmental regulations on innovation.

Recently, Rennings and Rammer (2011) differentiate the impacts further and find different effects when looking at the various environmental regulation that triggered different types of innovations. For example, regulations in favour of sustainable mobility increase turnover with market novelties, while regulations in the field of water management lower this type of innovation success. Furthermore, new processes implemented in order to comply with environmental regulation requirements lower profitability, indicating higher compliance costs for this type of innovation which cannot be passed on customers. In contrast, higher profit

margins can be observed in companies with innovations triggered by regulations on recycling and waste management as well as on resource efficiency. Finally, they also find winners and losers related to specific regulations, e.g. the innovators in the vehicle sector, like the suppliers of the automobile industry, have achieved above average sales shares, whereas the adopters of these innovations in the transport industry had to pay the costs, and may have in fact experienced a loss of competitiveness.

Walz (2007) and Walz et al. (2008) extend the assessment of regulation influencing innovation by integrating it into an innovation system approach and into a whole set of innovation policy instruments. Their findings underline, like Johnstone et al. (2010) and Rennings and Rammer (2011), the need for technology specific analyses, but also confirm the effectiveness of demand side regulations (see OECD (2011) for an overview of demand side innovation policies) to promote renewable energy technologies, e.g. the regulation of feed in tariffs in the case of wind power technology (Walz 2007) or in the case of solar energy (Johnstone et al. 2010).

In contrast to the numerous and increasing number of studies about the impacts of environmental regulations on innovation, the other two areas addressing workers' and consumers' safety have not been investigated at all or only very little. Besides some sector specific regulations, e.g. in the pharmaceutical industry, Unnevehr and Jensen (1996) investigate safety inspection regulations in the meat industry. They conclude that this command-and-control regime is more efficient than potential incentive-based regimes, because the inherent information asymmetry in the meat market makes it difficult for consumers to make the right choice. In contrast, Henson and Caswell (1999) argue that command-and-control regulations restrict the freedom of food suppliers in controlling food safety and consequently also innovation.

**Table 3: Incentive effects and compliance costs of social regulations[3]**

| Type of regulation | Compliance cost or negative incentive effects | Positive incentive effect | Empirical evidence |
|---|---|---|---|
| Environmental protection | Restricts innovation and creates compliance costs | Creates incentives for development of new eco-friendly processes and products (incl. environmental technologies) by creating temporary market entry barriers | Mainly positive |
| Workers health and safety protection | Restricts innovation and creates compliance costs | Creates incentives for development of processes with higher workers' safety by creating temporary market entry barriers and monopoly gains | Not available |
| Product and consumer safety | Restricts innovation and creates compliance costs | Increases the acceptance of new products among consumers and promotes their diffusion creating innovation incentives | Limited ambivalent evidence |

[3] Based on Blind (2012).

## 2.3 The impact of institutional regulation on innovation

### 2.3.1 Theory

Besides single specific economic and social regulations, the institutional framework implemented by administrative regulations is essential for the analysis of regulation and innovation. Two approaches have been developed to link the legal framework to innovation.

The economic analysis of law has also focused on how the legal environment influences economic efficiency, including innovation. In particular, the impact of liability rules on innovation, especially in the domain of product safety has been analysed. If liability rules are too strict, innovators do not introduce new products and services in the market, especially radical innovations, because the risks are high, the expected revenues decrease, and the users of the products reduce their self-protection efforts, leading to more accidents. Viscusi and Moore (1993) confirm empirically that very high levels of liability have negative effects on product innovation. However, without product liability, the acceptance of new products among consumers is reduced which may prohibit their success in the market.

In addition to liability laws, there are regulations related to the input factors labour and capital, which are important for innovation and will therefore also be addressed. The theoretical effects of labour regulations such as employment protection legislation on innovation are ambiguous. On the one hand, employment protection legislation increases job security for employees by the more efficient enforceability of job contracts. This security may increase workers' incentives and consequently investment in innovative activity, e.g. because they may participate in the future profits derived from successful innovations. On the other hand employment protection legislation increases the adjustment costs for firms, especially in case of failures, and this may lead to under-investment in activities that are likely to require adjustment, including risky innovations. In summary, we have contradicting impacts of employment protection legislations. The net impacts will obviously depend on the type of innovation, i.e. radical or incremental and the time horizon to achieve it.

At the capital side the regulation of the finance sector is important, but already covered in the overview of sector regulations. Therefore, we focus on bankruptcy laws, which have implications on funding innovations, but also on the incentive to start a business at all, i.e. the inclination to become an entrepreneur. Many innovations are financed by funds external to the company. Besides the different cost of capital, the risk of bankruptcy has to be considered. Creditors prefer in case of bankruptcy liquidating assets. Acharya and Sibramanian (2009) can prove in a theoretical model that stronger creditor rights will lead to less investment in innovation and more in well established production.

The link best analysed between administrative or institutional regulation and innovation is the impact of Intellectual Property Rights (IPRs), especially patents and copyrights, on innovation. Besen and Raskind (1991) point out that the fundamental dilemma lies between invention and diffusion. On the one hand, a strong patent protection encourages innovation. On the other hand, a weak one favours a rapid and wide diffusion of inventions, which leads to innovations and growth for the whole economy. Appropriate licensing schemes may be a good way to reach the two goals simultaneously. Since innovation processes differ across industries, optimal IPR rules should also vary from industry to industry from a purely economic point of view, although this is not practicable for the legal system. In general, institutional regulations can provide

positive incentives for innovative activities, but force suppliers of new products and services to introduce less risky products and services into the markets.

### 2.3.2 Empirical Evidence

In contrast to the large and growing literature focusing on the role of environmental regulations on innovation, we see only a few empirical studies on the role of institutional regulation. For example, the influence of liability schemes on innovation is only very selectively analysed. Viscusi and Moore (1993) find a positive influence of liability law on research and development in an US industry, if the expected liability costs are moderate, but a negative impact if the expected costs rise drastically. Other studies either show no impact on innovation (Papadakis et al. 1996) or even a tendency to promoting existing technologies (Parchomovsky, Stein 2008).

Labour market regulations can be divided into the system of wage setting, which is more a self regulatory regime composed by the labour unions and the employer associations, and the labour contracts between employers and employees. The majority of all studies on labour market regulations focus on their impacts on the development of unemployment and productivity. However, within the last decades first studies addressed the role of labour market regulations on innovation. At first, Eichengreen and Iversen (1999) postulated more decentralized and flexible labour market institutions, especially in science-based and high-skilled sectors referring to the disadvantages in Europe in relation to the labour market in the United States. Soskice (1997) and Hall and Soskice (2001) stress that the culture of high quality incremental innovation in Germany requires a solid consensus-oriented decision making based on significant power of autonomous skilled employees called coordinated market economies. The very deregulated labour markets in the liberal market economies of the US and United Kingdom do not provide these framework conditions, but are more favourable for radical innovations.

Whereas these early studies are based on qualitative and rather descriptive analyses, Bassanini and Ernst (2002) provide broad cross-country econometric evidence on the association of innovation patterns and different labour market institutional regimes. They use the R&D intensity in a cross-section of 18 OECD countries and 18 manufacturing industries for their empirical analysis. Specific dimensions of labour market flexibility are positively correlated with the level of R&D intensity (recently supported by Barbosa and Faria (2011) for the EU countries) in low-tech industries and in all industries in those countries implementing a rather decentralized wage-bargain regime with relatively little coordination between the different actors. In contrast, in countries with a strongly coordinated and centralized system of industrial relations the degree of the labour market flexibility is negatively related industries' R&D intensities, especially in knowledge intensive and specific areas. Bassanini and Ernst (2002) explain this observation with the existence of two opposite forces. On the one hand, especially process innovations in industries with restricted opportunities to open new markets and to increase their output are leading to a shrinking workforce. If labour market regulations are making adjustments in the employment of labour difficult or costly, e.g. by making reallocations difficult, then investment in innovation activities are discouraged. On the other hand, the compliance cost of labour market regulations created by restrictions in hiring and firing employees are rather low if employers are quite flexible in reallocating their employees internally in their company. Bassanini and Ernst (2002) also find empirical evidence supporting Hall's and Soskice's findings, because in knowledge intensive sectors relying on quite experienced workers, employment protection and a high degree of coordination in the

industrial regime, e.g. by arranging employees' and employers' aims, supporting company-internal and skill-specific trainings, lead to a higher level of R&D and innovativeness. However, Taylor (2004) and recently Akkermans et al. (2009) use more sophisticated indicators to test the argument of Hall and Soskice, which lead to a modification and further differentiation in the sense that sector characteristics do also play a significant role.

Saint-Paul (2002) derives from a theoretical model the hypothesis that countries with a rather highly regulated labour market produce goods, which possess a lower commercial risk, e.g. by improving already existing products being already at a later stage of their product life cycle instead of introducing rather innovative product innovations. Based on this theoretical argument Bartelsman et al. (2011) are able to show empirically, based on 30 industries of the OECD countries, that high-risk innovative sectors are smaller in countries with strict employment protection legislation compared to countries, like the US, following a more flexible and less restrictive employment protection.

Obviously, a strict regulation related to employment protection makes companies reluctant to invest in emerging technologies baring a higher risk to fail, because under such a regime it is more costly to get rid of the employees. Bartelsman et al. (2011) use their findings to explain the productivity slowdown in Europe relative to the US since the 1990s by the reluctance of European companies to adopt the emerging information technology.

Recently, Acharya et al. (2010) analyse the impact of wrongful discharge laws, i.e. laws that inhibit the common-law doctrine of "employment-at-will". Although, it is obvious that restricting an employer to terminate an unsuccessful employment contract ex post creates inefficiencies, this negative impact can be overcompensated by the positive effects that the laws limiting employment-at-will may have on ex-ante incentives. In particular, these laws might have the countervailing effect of committing companies not to punish short-run failures. Such commitment may spur employees to undertake risky but innovative activities leading to radical innovations and stimulating the creation of new and the destruction of existing companies. Acharya et al. (2010) can show that the wrongful discharge laws lead not only to more and better innovations in the affected US states, but also to more new companies being founded and more existing companies being closed. Ederer and Manso (2011) provide complementary evidence based on experimental studies that provide evidence that the combination of tolerance for early failure and reward for long-term success is effective in motivating employees for innovation.

Finally, Maré et al. (2008) and Kerr and Lincoln (2008) investigate the influence of immigration, which is heavily regulated, on innovation. However, they find either no influence or little influence on domestic innovation. Consequently, reducing the hurdles for foreign workers to enter domestic labour markets does not necessarily spur domestic innovation.

The few, but increasing number of studies on the impact of labour market regulations on innovation provide ambivalent evidence. The first studies argue and find empirical evidence in the line of reasoning that more flexibility leads to more innovation. This argument is certainly true in the short run. However, focusing on knowledge and experience based industries requiring a long term approach to innovation provides also evidence that regulations which commit companies to keeping employees under contract also in case of short term failure may spur innovation in general and especially radical breakthroughs in the long run.

There is little empirical evidence focusing on the relation between bankruptcy law and innovation. However, Armour and Cumming (2008) analyse the relationship between personal bankruptcy law and innovation in the sense of entrepreneurship using data on self employment over 13 years and 15 countries in Europe and North America. They construct a new index of the level of how 'forgiving' personal bankruptcy based on the number of years a bankrupt must wait until he may be discharged (if ever) from pre-bankruptcy indebtedness. Based on this index, they provide empirical evidence that bankruptcy laws have a statistically and economically significant effect on the levels of self employment, the inclination to become an entrepreneur. Precisely, they find that a 10 year reduction in the time to discharge gives rise to an increase in self employment rates by approximately 1.5% of the average level of self employment per population in the countries considered. In the same direction point the results by Primo and Green (2008), who explore the impact of US state bankruptcy laws on entrepreneurship and find that more generous bankruptcy laws increase the levels of self-employment. However, more generous laws are not linked to higher, but to lower levels of innovativeness of the analyzed entrepreneurs. Taking the very few theoretical and empirical studies on the impact of bankruptcy law on innovation, the expected positive relationship of more generous bankruptcy laws on the level of self-employment and therefore entrepreneurship can be confirmed. However, it remains unclear whether such generous treatments of bankrupts promotes entrepreneur into very innovative directions.

Finally, the regimes of intellectual property rights have been investigated in order to find empirical evidence for innovation promoting incentives and disclosure effects. In contrast to the expected and intended impacts, only very few studies like Koch et al. (2004) and Blind (2012) find a positive influence of the stringency of IPR regulations on the R&D intensity in former G7 countries. In general, studies focusing on the innovation promoting impacts of patents either find no significant positive influence, like Bessen and Meurer (2008), or even negative implications like Barbosa and Faria (2011) and Bessen and Hunt (2007) in the case of software patents on R&D activities in the United States. Also, Lerner (2009) who examines impacts of strengthening patent protection over the last 150 years, concludes that patents may actually discourage investment in innovation.

**Table 4: Incentive effects and compliance costs of institutional regulations**

| Type of regulation | Compliance cost or negative incentive effects | Positive incentive effects | Empirical evidence |
|---|---|---|---|
| Liability | Too high liability risks reduce the incentives to develop and market innovative products | Increases the acceptance of new products among customers and promotes their diffusion creating innovation incentives | Ambivalent |
| Employment protection legislation | Higher adjustment cost | Job security | Mostly positive depending on the type of innovation |
| Immigration | Integration costs | Immigration of foreign workers increases pressure on domestic workers | No significant impacts |
| Bankruptcy laws | Restrictions to acquire external funds for risky investments | Increased confidence of creditors to invest in innovation | Negative |
| Intellectual property rights | Restrict development (e. g. via patent thickets) and the diffusion of new technologies and products and the option to develop | Create additional incentives to invest in R&D by appropriating temporary monopoly rights (plus increasing R&D efficiency by disclosure of technological knowhow) | Ambivalent |

# 3 Lessons

As framed by the conceptual model and shown in the survey of empirical studies, the variety of regulations has different and often ambivalent impacts on innovation. They present a rather heterogeneous picture both regarding the area of regulation, the type of companies, the sectors, the type of innovation and the time horizon of the impacts incurred. The different impact directions and strengths among the three types of regulations have been expected in line with the predictions of the conceptual or theoretical models, especially in the area of environmental regulations.

Policy uncertainty, but also compliance uncertainty does appear to cause both negative and positive effects of expected future regulation on innovation. However, the evidence collected confirmed that policy uncertainty causes companies to delay investment and consequently innovation decisions. More precisely, companies will delay or reduce innovation activities the higher the level of uncertainty and the larger the differences in the expected profitability of innovation investments. In contrast, flexible regulations, including incentives-based regulation and performance standards, tend to promote innovation by maximizing the implementation leeway for companies to implement cost efficient and commercially attractive solutions. In addition, regulation that promotes more complete market information also fosters innovation, e.g. by reducing information asymmetry on the consumer side or by promoting innovative solutions on the producer side.

There is a clear divide between the effects of economic regulation and the effects of social regulation. Economic regulations have ambivalent impacts on innovation, whereas social regulations tend to stimulate innovation, because they require compliance innovation, e.g. in order to correct for negative environmental externalities. Confirming Porter's Hypothesis, some social regulations led even to the development of completely new markets. This is more likely the case, when social regulations are more stringent and disruptive in order to achieve challenging societal or environmental objectives, because then they tend to promote more radical innovation, whereas the moving target approach of gradually increasing stringency over time is more likely to result in incremental innovation. In contrast, stringent economic regulation, being largely detrimental to innovation, should be implemented in a more flexible way in order to minimize the compliance burden and thus its negative impact on innovation.

Finally, the studies also show differences between short and long term impacts. The short term impacts of regulations are often negative for innovation in contrast to the long term implications. Finally, it should be noted that the impacts are not time invariant, i.e. previous studies find slightly more negative impacts, whereas more recent investigations tend to reveal more positive implications especially of environmental regulations.

Although not explicitly addressed in this survey as there is no sound existing empirical analysis, there *appears* to be a significant lack of an innovation culture or awareness regarding innovation within the regulatory bodies (Blind et al. 2004, BERR 2008). Furthermore, the various interest groups and stakeholders involved in the regulatory process are also often not aware of the opportunities innovations can have on their own interests.

Despite the progress in the investigations focusing on the effect of regulation on innovation, three major research gaps can be identified in addition to the gaps in the areas already covered by single or even several studies. At first, the available existing indicators measuring the

regulatory framework and specific regulations have to be further developed and specified, because the ambivalence of the current insights is also caused by heterogeneous measurement approaches not only related to innovation, but especially to regulation. Some studies already show differences of the impacts of regulation on product and process innovation on the one hand and radical and incremental innovations on the other hand. More challenging is the construction of regulatory indicators reflecting differences in the development, e.g. uncertainty in the policy process, the implementation, e.g. stringency, and other aspects of regulations. Secondly, the specific reactions inside companies towards existing and new regulations are still mainly treated as black box processes. Here, more in-depth investigations are required, which include the different units and activities of companies besides R&D. Finally, most studies treat regulations exogenously. However, often there is a close interaction in the development of regulations between the regulators and the regulated companies. This interaction has implications for the impact of regulations on innovation and might also explain different impacts both for different types of innovations and companies.

Based on the general insights from the conceptual approach, the empirical impact analyses and the research gaps, the following proposals for more innovation-friendly and even innovation targeting regulatory policies (see also Blind 2010) can be derived:

- **Strengthen the focus on innovation in regulatory policy.** Regulatory bodies responsible, for example, for the protection of competition, health and safety or the environment, should give more consideration to the opportunities of innovation in general for achieving their traditional goals. Also the major stakeholders in setting regulations, especially consumer and environmental organisations, should systematically check the positive influence of innovation on their organisations´ objectives. In general, all these organisations and their actors have to develop some kind of innovation culture and sensitivity. The performance criteria of regulatory bodies should even include indicators measuring the promotion of new products and services in balance with their other objectives.
- **Increase the quality of the regulatory framework regarding innovation.** Regulatory bodies have to react more proactively to trends in science and technology relevant for their regulatory framework by intensifying the contact with the science and technology community, eventually implementing 'regulatory foresight' exercises (Blind 2008) or complementary 'standardisation foresight' (Goluchowicz and Blind 2011). Regulatory bodies should focus on those types of regulations or shape regulations in a way which maximises the positive and minimises the negative impacts for innovation (Stewart 2010), e.g. by fostering technology neutral or outcome-focused regulations (BERR 2008). In cases where the future regulation would demand innovation, the caused uncertainty for companies should be limited, although a moderate level of uncertainty might be useful as an early catalyst to start research and development. Finally, it should be considered to allow firms time to adapt to compliance, especially in the case of disruptive regulation.
- **Improve the implementation of regulations to foster innovation.** The implementation of regulations has to be harmonised in order to reduce the risk and the costs to companies introducing innovations. Approval times have to be reduced, if possible and not challenging the acceptance of the consumers, since they are very negative for the expected return of investment in long-lasting and expensive R&D resulting in innovative products and services. The transition of regulatory bodies into

service providers for the general public and also for companies, represents a promising strategy, especially if the staff is equipped with innovation related know how and is guided by innovation supporting strategic goals, which also promotes their general support for the introduction of new products and services.

- **Include innovation in ex ante and ex post regulatory impact assessments.** For example, the European Commission has started to take innovation as one impact dimension into account, but this needs to be fostered, specified and accompanied by methodologically advanced impact assessment tools, which both take into account the impacts on innovation inputs, i.e. research and development, and the various types of innovations, e.g. product or process innovation,.
- **Optimise the frequency and timing of reviewing existing regulations.** Regulations have to be adapted to new insights from science and technology, but also to changes in markets and societal preferences. However, too frequent reviews of regulations may increase companies' risk and thus reduce the expected returns to investments in innovation. Consequently, these effects have to be considered in order to avoid disincentives to innovation where possible (BERR 2008).
- **Coordinate the policies of all relevant regulatory bodies to foster innovation.** Since innovation is a complex process and the different types of regulation interact, the promotion of innovation by regulatory policies requires a comprehensive approach, co-ordinating or even integrating the regulatory policies of all relevant regulatory bodies; for example, it is not sufficient to set a favourable framework for research, it is also necessary to stabilise the demand for innovative products and services (see Walz 2007 and Walz et al. 2008).
- **Move innovation into the centre of public policies in general (Blind and Georghiou 2010) and in the set of objectives and the general culture of regulatory bodies in particular (Stewart 2010).** The review confirmed that the instrument of regulation has been actively and successfully used especially in environmental policies. However, most research, development and innovation policies themselves, with very few exceptions, e.g. the German HighTech Strategy and the Lead Market Initiative of the European Commission, have not taken this opportunity into account. Even the two above mentioned exceptions have not exploited the potential of regulations to promote innovation and thus to increase the efficiency of the general policies or to achieve more ambitious goals.
- **Integrate regulation in the research on innovation systems.** Finally, the various regulatory bodies and their policies should also be integrated more explicitly in a comprehensive innovation system approach by innovation researchers providing also a broader and sound basis for innovation policy makers to take regulation and their institutions as effective and efficient innovation policy instruments into account.

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