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Ex post evaluation of EC merger decisions: two empirical analysis of prices and patents

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Statutory Declaration

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Abstract

The objective of this thesis is to analyse the impact on prices and patents of two mergers that were cleared by the European Commission in the energy and in the pharmaceuticals sectors. The literature review finds that ex post evaluation of mergers is a popular tool for competition authorities, used all over the world in order to obtain useful information to ensure proper competition policy enforcement. Innovation has been taken into account more and more often in the Commission assessment of mergers, but there is still a lot of potential for research. This empirical analysis is developed two-fold and is conducted based on two databases: the first dataset of variables is related to the energy sector prices from 1999 to 2015; whereas the second dataset of variables is based on the pharmaceuticals sector patents from 1995 to 2013. The empirical results obtained by the estimation of Difference-in-Differences models suggest that the Commission decisions were correct and that the impact on the markets and innovation was positive. In the DONG/ELSAM/Energi E2 case, prices decrease both in the consumer and industrial end users scenario. In the Sanofi-Synthélabo/Aventis case the number of patents applications increases both in the long and short time frame, and are confirmed by the placebo tests performed.

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1. Introduction

The aim of competition authorities all over the world is that of making sure that undertakings compete in a fair way. In order to prevent competition to be hampered, those authorities often make use of counterfactual analysis so that future possible outcomes can be forecast. Nevertheless, it is less popular among those competition authorities to perform an ex-post analysis of what really happened to the competitive environment after the decision (Pires, 2015). The latter activity is a crucial part in the understanding of whether competition policy rules and those methodologies applied by competition authorities are in fact successful. This kind of analysis can give an input to correct those. It would be therefore possible to understand whether the guidelines and rules applied are excessively strong or weak (Hosken, 2011; Kwoka, 2013).

The ex post analysis of past decisions can give a much clearer idea of to what extent a judgement was correct since the use of parametric assumptions of structural models would not be required at this stage (Nevo, 2000). Many more effects generated by the merger would finally be noticed thanks to these analyses ex post that were not expressed by the counterfactual analysis ex ante. Thanks to the abundance of data it is possible to study the effects of mergers in an empirical way rather than by simple sector interviews, getting a glimpse of the effect especially over prices (Farrell et al., 2009). Retrospective merger analysis should therefore be used to evaluate the capability to assess a merger and to estimate if a concentration would drive up prices and have an effect on other factors such as innovation.

This thesis work is developed two-fold. The first part of this paper concerns the ex-post evaluation of prices after a merger in the energy sector, the most common variable of analysis across all competition authorities. A healthy and competitive energy sector is crucial for the welfare of society. Energy is crucial for the life of consumers and undertakings of all sorts. Therefore great attention should be paid to it in order to achieve a more competitive EU across all industries. Nevertheless certain industries such as electricity and gas have structural network characteristics that may allow the key players to abuse of a dominant position in

the market, hampering competition and increasing prices. This would constitute damage to consumer welfare and to all industries.

Over the past two decades we have been able to notice that three major structural reforms have shaped the energy market all over Europe. This regulatory driver was not sufficient to tackle competitive concerns in all the industry. Some parts of the markets are by their nature better off under a monopolistic ownership and coexist with other sectors that have been opened to competition. Several indicators show that the market may not have been completely freed from competition constraints since prices growth, few cases of new players entering the market, great market shares and a low confidence by the consumers (Wilkinson, Duso et aliud, 2015). Apart from regulatory intervention, the European Union has also focused its efforts to tackle issues in the market through competition policy and merger control.

Concerning concentration in energy markets in the European Union, Merger control put in place by the Commission has been a central actor in fostering a more competitive environment in this market. These are for example the cases of GDF/Suez (2008), which created concerns in the Belgian wholesale market, and Electricité de France S.A. (EdF)/British Energy (2008), which would have potentially reduced liquidity and demand foreclosure in the British market. The Commission (2015) performed an ex post analysis of GDF/SUEZ concentration finding that the decision affected the European Energy Exchange reducing electricity prices in Germany. Several mergers were cleared with the use of remedies such as in the case of DONG/Elsam/E2 which will be further analysed in this study and was approved after a phase two investigation. Nevertheless the Commission has also prohibited some concentrations which would have hampered competition and for whom the remedies provided by the parties involved didn't seem to be enough to stem a clearing. This is for example the case of EDP/ENI/GDP.

The second part of this study is related to the analysis of innovation through the ex post evaluation of patenting activity in France in the pharmaceutical sector after a merger cleared by the Commission with remedies. Ex post evaluation of dynamic aspects of the market and of patents is crucial to foster the competitiveness of our

economy, which is more and more based on the added value provided by technological innovations. It is therefore essential to focus economists' attention on innovation, which has become an important variable in the assessment of mergers by the European Commission and a main driver in the creation of growth, jobs and investments (Competition policy brief, 2016).

It seems that the Commission has started to take more into account the importance of innovation and of dynamic efficiencies during its assessment. The legal framework in place is able to capture those aspects of the analysis related to innovation. The later has been demonstrated by a growing number of cases in which the Commission has mentioned and tried to deal with innovation. This is the case for example of Medtronic/Covidien, Novartis/GlaxoSmithKline's, Pfizer/Hospira, General Electric/Alstom, Deutsche Börse AG v European Commission, Intel/McAfee, ARM/Giesecke & Devrient/ Gemalto Joint Venture, Intel/Altera. Among the cases in which innovation efficiencies were claimed by the parties TomTom/TeleAtlas was one of those in which the efficiencies were partly recognized. It would nevertheless seem from the opinions of several authors that there is still space for improvement and that economics could provide better guidance to policymakers in this area (Curzon Price and Walker, 2016).

This thesis is organized as follows. Section 2 presents the theoretical and methodological basis of the research. Section 3 provides and introduction to the DONG/ELSAM/E2 case as well as the description of the data used for the purpose of this study. Section 4 summarizes the empirical results and model estimated in relation to gas prices for consumers and industrial end users. Section 5 focuses on the SANOFI-SYNTHÈLABO/AVENTIS merger and provides both an analysis of it and an explanation of the dataset used for the purpose of its analysis. Section 6 summarizes the empirical results and model estimated on patents. Finally section 7 presents the conclusions to this thesis work.

2. Review of the existing literature

In this chapter the main existing literature on previous studies conducted in the same field of this paper will be analysed. A first part will review the publications on ex-post evaluation of mergers in general. The second part will be devoted to the analysis of the literature concerning mergers in the energy sector. The third part will work as a review of the literature for the second part of the study, which is related to dynamic efficiencies and innovation in merger control. Finally, the fourth and last part will be dealing specifically with mergers in the pharmaceuticals sector and with previous Commission decisions dealing with innovation.

2.1. Ex-post evaluation of mergers

According to a paper written by Bundzinski (2013) competition policy is an essential condition to the existence of the free market. Companies may try in different ways to reduce competition in the market rather than making the effort of improving itself more than its peers. One of the above mentioned conducts is for example that of acquiring its competitors. Merger regulation and its enforcement through decisions by the Commission are essential to the prevention of those acquisitions which would result in an anticompetitive concentration of ownership. The author states that those decisions are not always correct and that the impact on competition can relate to several dimensions including: price, quantity, variety, innovation, etc. It is not easy to scientifically state which dimension should be considered more important, but prices and quantities are easy to measure and therefore are the most common variables in merger decisions. Bundzinski (2013) finally states that because of this likely imprecision of measurement, merger decisions may be wrong in two ways: a procompetitive merger can be prohibited (type I errors); an anti-competitive merger can be allowed (type II errors).

There can be different reasons for wanting to evaluate a decision ex-post from an economic perspective, such as to improve merger control, to reinforce the accountability of the agency and of the regime (e.g. Davies 2010). Depending on the motivation driving the assessment of the decision, and the resources available, different methodologies will be chosen rather than others. Those methodologies are characterised by different reliability of results, applicability to certain cases and conditions, and resource intensity (Bundzinski, 2013). It is possible to use more

than one evaluation technique in order to improve the reliability of the results (Buccirossi et alia, 2008). Therefore, the most popular methods that can be used are: structural models and simulations, difference-in-differences (DiD) approaches, event studies, surveys, and case studies.

Concerning Merger Simulation Models, according to (Bundzinski, 2010), an ex-post analysis is key to understanding whether the ex-ante tool was indeed correct. Nevertheless few ex post studies of this kind have been produced and the results were mixed. During a policy roundtable of the OECD (2011) in which 19 countries[1] deposited a written report, the conclusions were that structural models were the most developed tool available but that some limitations needed to be taken into account. For example those models are based on different oligopoly models (e.g. Cournot and Bertrand) and are bound to those; so only cases which respect the assumptions can be represented correctly by the simulation. Moreover, even if they can't reproduce the market perfectly, they require a great amount of data and econometrics knowledge.

Always according to the outcomes of the OECD roundtable (2011), the difference-in-difference methodology requires an appropriate identification of the right counterfactual market/scenario. The market should be similar to the treated one but at the same not affected by the treatment (Bergman, 2008). Less data and econometric skills is required for the Difference in Difference tool since the model is less based on economic theories (Bundzinski, 2013). The most difficult part is usually the identification of the right control market, which is not always reliable and applicable to all the cases (Davies, 2010). Finally, in the case of those mergers that were not prohibited in the past, this methodology is not suitable for an ex post evaluation (Bundzinski, 2013). This model is the one which is chosen for the purpose of the empirical analysis that will follow in this study.

Concerning event studies, those are less limited by data constraints since the methodology uses information on stock prices variations which is easier to obtain (Ellert, 1976). Nevertheless firms should be listed companies and be present mainly in one market that can be identified as the affected market. In addition to

[1] Namely Brazil, Belgium, Canada, Chile, Estonia, EU, Greece, Hungary, Indonesia, Japan, Korea, Netherlands, Norway, Poland, Romania, South Africa, Switzerland, UK, US.

those concerns, the methodology is based on the hypothesis that financial markets are efficient, which is not an assumption met perfectly in practice (Bundzinski, 2013). Previous papers try to show how the effects of mergers are not processed correctly by the markets and how the event study fails to provide a good prediction (McAfee and Williams, 1988). Therefore it is not sure that those models provide reliable results, but competition authorities still consider it a methodology that can contribute with a useful insight (OECD, 2011).

Among more qualitative methods are surveys, which can also add useful information for the assessment of mergers ex post (OECD, 2011). Since surveys are based on interviews and questionnaires, it is a tool that doesn't require a lot of data but at the same time the results can be biased by non-precise questions and by the assumptions this methodology is based on. Precise information should be possessed by the interviewees and they should be able to disclose it (Bundzinski, 2013).

According to Davies and Ormosi (2010), expert case studies are, in contrast to surveys, the review of one single expert and not the opinion of several insiders. These studies comprise a mix of the previously described tools, being therefore subject to the related limitations. Experts may give a biased opinion of the cases, influenced by reasons and purposes that may not be those of producing an objective and critical review (Bundzinski, 2013).

From the OECD roundtable meeting (2011), it was possible to notice that the DiD approach was the most popular quantitative methodology among the 19 participating entities, followed by structural models and event studies. Surveys were the most preferred methodologies, which constituted almost half of the analysed sample.

This shows that ex post evaluation of merger decisions can be considered a good way of creating information on how the rules of competition policy work and on how to ameliorate the existing regime ex ante techniques rather than checking previous decisions correctness. Economics could therefore play an important role in shaping competition policy thanks to the information provided by ex post evaluation of mergers (Baker and Shapiro, 2008).

The next steps that could be taken in the ex post evaluation of merger decisions are related to a more uniform methodology with different stages of implementation (Gavil, 2011). Ex post merger evaluation is now a practice recognized to be useful for several reasons, the next step would be that of identifying, at an international level, the best methodologies which constitute the 'state of the art', creating a Handbook on ex post evaluation of mergers which would then serve as a harmonization driver. Gavil (2011) states that most of the agencies wouldn't be able to implement the entire ex post evaluation tools set which constitutes the 'state of the art', requiring therefore an implementation through different stages. These stages depend on the level of skills, experience and resources available in each agency. The guide on the best practices would be an important document for newly created agencies and for a homogeneous ex post evaluation of mergers which would likely improve their future performance.

Gavil (2011) creates a list of four options which can be implemented in order to allow for a staged implementation of ex post review. Simplified and more basic Difference in Differences models could produce significant and useful results that wouldn't need extensive data and resources by less developed agencies. Event studies could be implemented through more rudimentary models and could give an initial idea of the effect of a merger decision, especially in the case of companies that sell one product and are at the same time listed in the stock market. Agencies could be able to monitor the outcome of a merger thanks to the data collected for the purpose of a new merger ex ante evaluation in the same sector. Other options such as using newly obtained data from new mergers in order to assess previous ones would, on the one hand remove data and resources constraints, but on the other force new parties to provide excessive amounts of data. Finally, the fourth option identified consists in getting the agencies to 'planting seeds' for future data collection and analysis during the study of a merger case, especially when cleared with remedies and conditions. This last possibility would imply future reporting requirements and might not be always available.

Thanks to this staged implementation of ex post review it would be possible to include all the agencies in the world in the process, allowing them to grow in expertise and improve their techniques towards the so called 'state of the art' of ex post evaluation of mergers. This would make sure that ex post evaluation, an

extremely important activity for competition policy, is implemented on a global scale.

2.2. Merger control in the energy sector

Within the area of merger control in the energy sector, there are few authors that provide their point of view and analysis. For example Pozzi (2004) identifies the reasons and the impact of competition policy in the Energy sector in the United States with the use of empirical methodologies. Thanks to the research performed by Pozzi, some evidence is found that the profitability of the electricity sector decreases, whereas there is no influence on the gas and oil sector. Nevertheless there is a decrease in the margins of the downstream sector.

In a paper written by Federico (2011) the effect of mergers on the competitiveness of energy markets was analysed. It considers the ten greatest deals that took place in the European Union and in Spain from 2004 to 2011. The research finds that the major concern of the competition authorities in the energy market has been directed towards possible horizontal unilateral effects. The author also points out that those concerns rose for firms holding a small share of the market. For what regards the non-horizontal possible effects raised by concentrations in the energy market, among several theories of harm the major concerns relate to the consequence of an increased use of gas for the generation of electricity and reduced unbundling of network infrastructure. Remedies usually involve divestment in key assets in order to eliminate possible constraints to competition. Among the most effective and required divestitures, it is possible to notice that the Commission tends to prefer assets such as price-generating plants, network structures, ownership in competitors' capital.

A part of the literature (Hunger, 2003; Verde, 2008) focuses on the convergence mergers. Those are related to merging entities coming from wholesale gas sector and from the electricity sector. The reason for this is that many customers prefer to be offered both gas and electricity by the same customer and that the mergers are vertically connected since gas is being used more and more often in the generation of electricity. Researchers have analysed the incentive that newly merged entities could have to foreclose those rivals that do not include both gas and electricity (e.g. Rey and Tirole 2004).

Some authors claim that the increased prices are due to several reasons among which the loss of oil producers from having higher costs in the extraction than revenues from the market, the need for firms that generate electricity by using oil to add all costs and margin in the price, among which the oil cost (Rupérez-Micola et al., 2008). Other potential competitive constraints can be related to the customer and input foreclosure issues related to the energy industry, since firms may want to increase prices for the downstream client or may try to foreclose customers dissuading new entrants and hampering the position of already existing firms (Federico, 2011).

Concerning vertical integration, Newbery (2007) finds that the latter can create efficiencies by internalizing risks complementary for generators and suppliers. Nevertheless it may also create a shortage of liquidity and therefore cause a threat to competition by dissuading new potential entrants (Ofgem, 2015). Fiorio and Florio (2009) have provided evidence that vertical integration leads to higher final consumer prices in the electricity market.

According to Chao et al. (2005) relationships in the form of long term contracts has the same effect as the vertical integration but lacks the investment and the control centralization. So both the positive effects, namely fuel mix, risk sharing, etc. and the negative effects for competition stay almost the same as in vertical integration.

Concerning ownership unbundling Meyer (2011) finds that in the electricity market this practice causes a loss in synergies that ranges from 17 percent to 2 percent depending on the product market taken into account. Nevertheless the literature is controversial for what concerns improved efficiency in the whole sector given different results obtained by different authors (Steiner, 2001; Hattori and Tsutsui, 2004). Moreover it is not clear whether unbundling stimulates investment and passes the surplus obtained by the efficiencies to the consumer (Wilkinson, Duso et aliud, 2016).

Concerning remedies, the Commission has cleared very important concentrations thanks to divestitures and behavioural remedies which have been quite demanding for the firms compared to the market share involved in the concentration (Federico 2011). It is for example the case of Dong/Elsam/E2, which will be the basis of the first part of the empirical analysis of this thesis. According

to Verde (2008) remedies can have negative overall effects if the party to which the plant is divested is not expert or capable to run the business effectively, promoting competition and offsetting loss of efficiencies deriving from the total concentration.

2.3. Innovation, Antitrust and merger control

The competitiveness of our economy is more and more based on the added value provided by technological innovations. It is therefore essential to focus economists' attention on innovation, which has become an important variable in the assessment of mergers by the European Commission and a main driver in the creation of growth, jobs and investments (Competition policy brief, 2016). The EU legal framework doesn't provide a definition of what is innovation, but the Commission proposes several distinctions of innovation, derived from economic and business literature:

- Product vs. Process innovation: the former refers to the implementation of a new product with ameliorated features, whereas the latter is related to creation and delivery amelioration;
- Incremental vs. Breakthrough innovation: the two refer to the magnitude of the technological progress, which is smaller in the first case and greater in the second (Bower et aliud, 1995);
- Sustaining vs. Disruptive innovation: the first term refers to an innovation which takes place within an established 'value network', whereas the second term embraces the concept of creating a new 'value network'. (Competition policy brief, 2016).

However, even if the commission seems to be moving towards a more innovation focused approach, T.Curzon Price and M.Walker (2016) mention that there is still a lot of room left for potential improvement, especially stating that: "dynamic efficiency is often the neglected child of competition policy, even though it is a recognised driver of long-term increased living standards".

It is possible to distinguish between static and dynamic efficiencies in a competitive market. The former can be either allocative or technical. Allocative efficiency is obtained when price and marginal cost coincide, whereas technical

efficiency requires costs to be at the lowest possible level for given knowledge and input. Dynamic efficiency involves the creation of new products or the increase in the quality of the existing ones, as well as the design of new processes (Curzon Price and Walker, 2016).

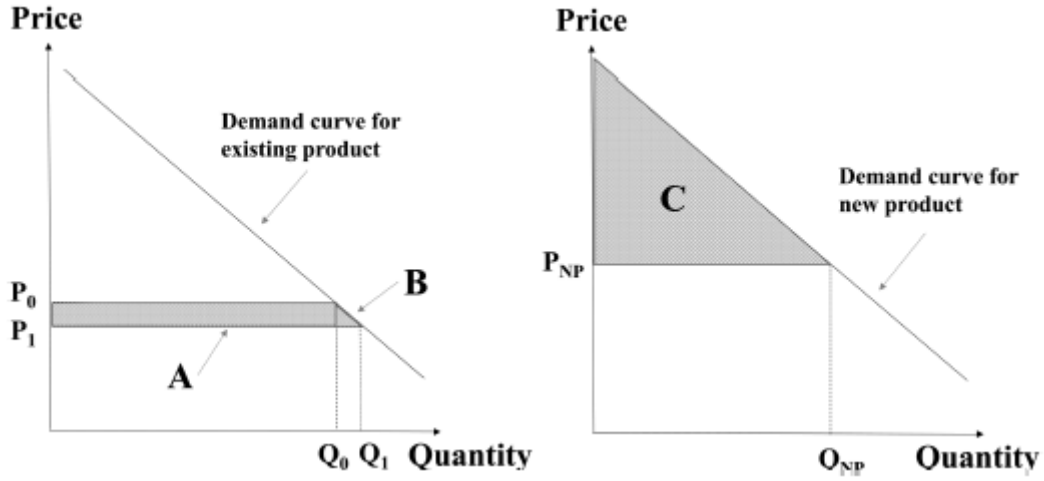


Figure 1: Static v dynamic welfare gains. Source: 'Incentives to innovate v short-term price effects in antitrust analysis', T. Curzon Price and M. Walker, Journal of European Competition Law & Practice, 2016, vol. 7, no. 7

As it can be seen in figure 1 above, dynamic efficiencies could be preferred over static efficiencies since the former would lead to the creation of a completely new demand curve for a new product, which increases consumer welfare by the area C, rather than just a small increase of A + B in the latter one (Curzon Price and Walker, 2016).

Several authors have tried to identify the relationship between competition and innovation. For example Joseph Schumpeter (1942) developed a theory of continuous innovation and creative destruction, stating that a less competitive environment would stem innovation, especially dynamic. This is due to the fact that less competition is linked to higher rewards for the producer, which would then reinvest those rewards into R&D, which would in turn produce more innovation. In this scenario firms compete for the market leader position rather than over price (Schumpeter, 1942).

Nevertheless Kenneth Arrow (1962) finds that more competition triggers a need to escape competition to earn higher profits, which can be achieved through more innovation. This low concentration implies stronger incentives to differentiate and

to innovate, whereas firms with a greater interest in the leading position have a smaller incentive to innovate than firms without such an interest (Arrow, 1962).

Moreover strong evidence was found that there exists an inverted-U relationship between competition and innovation, according to which laggard firms would produce less innovation and neck-and-neck companies would be incentivized to innovate more (Aghion et alia, 2005).

According to Carl Shapiro (2012) both Arrow and Schumpeter identified some important patterns of the relationship between innovation and competition. Arrow's view that company's vested interest in the status quo implies a lower encouragement towards innovation, which can be reconciled with Schumpeter's conclusions that, in order to foster innovation, a reward for innovation should be granted (Shapiro, 2012). Both authors find that profitable future sales competition is the key market characteristic that fosters innovation. Arrow would put more weight on the ex ante conditions, whereas Schumpeter would identify ex post. Therefore mergers and unilateral conduct can really have an impact on the incentives to compete and innovate (Shapiro, 2012).

Previous studies have demonstrated that M&As can improve the innovation performance. Authors have demonstrated that the greater the absolute size of the knowledge base is, the greater the innovation productivity will be (Ahuja and Katila, 2001). But not all M&As produce the same effects on innovation and an analysis of similarity and complementarity is crucial. Firms which belonged to a similar technological field undergo a period of rationalization and reduction of productivity (Cassiman et al., 2005), and further studies found that the relationship between innovativeness and similarity is an inverted U-shape (Kapoor and Lim, 2007). Moreover knowledge overlap generates a negative effect on the cumulative abnormal returns(Sears, 2014). But Firms complementary in technology and science have a good level of quality and novelty in inventions after the acquisition (Makri, Hitt, and Lane, 2010).

There are other factors that influence innovation activity after an acquisition. There is no negative effect on innovation activity because of layoffs in the R&D department, especially for what concerns the top management for which the reorganization improves R&D efficiency and productivity (Colombo and Rabbiosi,

2012). Improvement in innovation is more likely when routines overlap more, skills less and relative size of the target company is higher than the buyer's (Kapoor and Lim, 2007). Diversity in downstream resources has a positive effect on breadth and depth of innovation activity (Valentini and Di Guardo, 2012). There is some discrepancy between anticipated and realized synergies. Several factors influence innovation, and similarity is sometimes preferred as it can make integration easier (Rao et al., 2015). A buyer would usually acquire a firm with complementary products to its own, but with similar R&D pipeline to its products (Yu Yu, Nita Umashankar and Vithala R. Rao, 2015).

Even though it seems from previous studies that mergers have an impact on R&D and innovation, according to Curzon Price and Walker (2016) we haven't developed the right tools to evaluate dynamic efficiencies, often underestimating those. The creation of the economic models and theories that we rely on now were originated by past needs that derived from the circumstances of that generation. Therefore the current circumstances will be the driver for the creation of new studies that will improve our knowledge on topics such as innovation (Perez, 2003). It is therefore important that the best environment for innovation is created and maintained, which can be done also with the help of competition policy (Curzon Price and Walker, 2016). Among the features that should constitute this innovative environment should be: expectation of appropriable rents for innovators; disincentivization of non-innovating rent-protecting activities; optimal trade-off between static inefficiency and dynamic incentives; avoiding too high returns for innovation. Curzon Price and Walker (2016) suggest three topics where research should focus in the future: microeconomics models that explain what incentives have the greatest impact on innovation, creation of economic theories based on innovation case studies, undertaking ex post evaluation of decisions. The second part of this thesis will focus on that last area of research identified, providing an ex post evaluation of the patenting activity in France, compared to different scenarios.

2.4. Merger control and innovation, a focus on previous decision and on the pharmaceuticals sector

From what previously said it seems clear that the Commission has nowadays more at heart trying to foster innovation. It needs to be ascertained whether this is feasible through competition policy enforcement. The current EU Merger Regulation (2004) and relative guidelines take into account the effect that an uncompetitive behavior can have on innovation as well as the effect of higher prices, lower output and decrease in quality (Competition policy brief, 2016).

According to the European Commission's Horizontal Merger Guidelines (2004) the impact that a merger has on innovation is also taken into account among all the factors analyzed at the moment of a decision. The Non Horizontal Merger Guidelines (2008) also state that innovation is one of the key aspects that are scrutinized when the merger is controlled. In order to make the scope of the intervention of the Commission wider, small but innovative firms are considered even if they are just likely to expand in the near future. Efficiencies related to innovation can be accepted by the Commission given their impact on consumers' price, quantity, quality and welfare.

A paper written five years ago claimed the lack of dynamic efficiencies analysis by the commission in his merger decisions (Veugelers, Reinhilde, 2012). More in particular the article analyzed previous phase two merger decisions and arrived to the conclusion that out of 42 cases, dynamic efficiency claims were put forward in only 11 of those and had been accepted in only one case, but were not considered decisive even in that case.

Nevertheless, in the last years the Commission has found several behaviors, in cases such as horizontal and non-horizontal mergers, to have anticompetitive effects on innovation. This is the case for example of Medtronic/Covidien, Novartis/GlaxoSmithKline's, Pfizer/Hospira, General Electric/Alstom, Deutsche Börse AG v European Commission, Intel/McAfee, ARM/Giesecke & Devrient/ Gemalto Joint Venture, Intel/Altera. Among the cases in which innovation efficiencies were claimed by the parties TomTom/TeleAtlas was one of those in which the efficiencies were partly recognized.

The second part of this research will involve the ex post assessment of a pharmaceutical sector merger, namely Sanofi-Synthélabo/Aventis merger. It is therefore important to explain those that were the most important features of the latest cases in which the Commission considered innovation in its decisions.

The merger between GSK and Novartis of 2014 involved two companies whose main economic activities consisted in the development, distribution and marketing of pharmaceutical products. The merger was cleared but was conditional on the divestiture of several drugs. The Commission feared that the deal would have hampered competition and innovation in those areas to be divested. More in particular the Commission feared that the new duopoly market structure would have been less competitive especially in relation to the creation and sales of B-Raf and a MEK inhibitors for skin cancer. Moreover, some of the trial programs would have likely been completely stopped, reducing innovation further. The concentration would have reduced competition in skin cancer treatments but Novartis proposed to return its rights over MEK162 to Array BioPharma Inc. and to divest LGX818 to Array.

Another example of horizontal acquisition in the pharmaceutical sector in which innovation played a key role was given by the Pfizer/Hospira case. The Commission ultimately found that the proposed merger could have hampered competition and reduced innovation because it would have led the new entity to stop developing the new infliximab biosimilar drug or would have reduced current price competition. Biosimilar drugs are product substitutes of biological drugs for consumer, without infringing patents as it would be the case of generics. Moreover competition concerns were identified also in the case of the sterile injections market. The remedies were accepted by the Commission, which found that a divestment of infliximab biosimilar and a divestment of marketing authorizations for sterile injectable would have avoided all the competition concerns initially identified.

Remedies in horizontal and non-horizontal mergers have usually been related to the divestment of those projects and patents that are still in the development phase and pipeline. In the case of non-horizontal mergers remedies may also be of the behavioral type (Competition policy brief, 2016).

For example in the case of Intel/Mc Afee merger, the competitors of McAfee would have likely been foreclosed the access to those markets in which Intel was a dominant provider of central processing units and chipsets. Innovation was likely to suffer from this foreclosure since Mc Afee's current and potential competitors wouldn't have been able to participate in the just mentioned markets. Therefore behavioral remedies were accepted by the Commission. Those involved, among other commitments, the guaranteed access by Intel for Mc Afee's competitors and a more secure arbitration system to settle disputes related to the matter of interoperability.

Finally an interesting case which is worth mentioning is that of TomTom/TeleAtlas, in which the Commission acknowledged the innovation synergies and efficiencies that would have been generated by the merger. The deal was cleared by the Commission and not subjected to commitments. The main efficiencies that were found were related to the elimination of double margins as a direct result of profit maximization and it took into account the elimination of double margins. Moreover there would have been small average price decreases. The innovation efficiency was related to better and faster maps. Nevertheless the parties failed to quantify rigorously the effect on innovation and the merger was cleared because of other argumentations.

It seems that the Commission has started to take more into account the importance of innovation and of dynamic efficiencies during its assessment. The legal framework in place is able to capture those aspects of the analysis related to innovation. The later has been demonstrated by a growing number of cases in which the Commission has mentioned and tried to deal with innovation. It would nevertheless seem from the opinions of several authors that there is still space for improvement and that economics could provide better guidance to policymakers in this area (Curzon Price and Walker, 2016).

3. Descriptive statistics and case study summary of the merger DONG/Elsam/E2

In the following chapter, a summary of the key elements of the DONG/Elsam/E2 decision will be provided in order to create the basis for an understanding of the empirical analysis. Further on a descriptive analysis of the data will be conducted.

The case M.3868 DONG / ELSAM / ENERGI E2 was submitted to the Commission on 13th September 2005 and was cleared with remedies on 14th March 2006. The case was downloaded from the Merger Research Tool of the DG Competition website. The NACE codes used for the purpose of the research are D.35.1, which stands for electric power generation, transmission and distribution and D.35.2 which stands for Manufacture of gas; distribution of gaseous fuels through mains. This case was identified by Federico (2011) as one of the most relevant mergers in the energy sector.

3.1. Review of the case

In the initial concentration that was notified to the Commission in 2005, DONG wanted to acquire the control of Elsam, E2, KE and FE. DONG, a Danish state-owned company, operated in the gas sector in the fields of generation, distribution and retail of oil and natural gas, storing and distributing natural gas, as well as in smaller businesses in the production, and offer of electricity. Elsam and Energi E2 (E2) operated respectively in the western and eastern parts of Denmark in the generation and wholesale of electricity. Nevertheless E2 had also an important activity in the retail to customers. KE and FE were the suppliers of electricity of Copenhagen region.

The relevant product markets for natural gas were defined by the Commission following an analysis of the markets for gas storage/flexibility, wholesale and supply. The definition of the relevant market for the storage/flexibility business was left open, a conclusion stemmed by the market investigation provided by the Commission which showed five different possible groups of flexibility tools not to be considered as viable. Concerning the wholesale market, the final decision identified a market independently of the legal instrument used for the transaction. With regard to the Market for supply of natural gas to central CHP plants, the

Commission claimed that it was a separate market given its different consumption patterns. Concerning markets for supply of gas to decentral CHPs and to large industrial customers, the Commission found that this could have been considered both as a single and a separate market. Finally, the Commission found the market for supplies of gas to households and small businesses to be considerable as both the same market and two separated markets. The Commission identified Denmark (or possibly Sweden in few cases) as the only main relevant geographic market for all the relevant product markets.

The relevant product markets that the Commission identified in the electricity sector were: wholesales within the Nord Pool, ancillary services and bilateral wholesales outside of the Nord Pool. The above mentioned electricity product markets had a geographic market national and not greater than Denmark (or possibly Sweden). Another product market that is defined in the Commission analysis is the one of financial derivatives of electricity, which instead of exchanging electricity was in charge of allocating risks and should have been located in the whole Nordic relevant geographic market. Eventually the contracts for difference could be considered as a separate product market with the same geographic scope. Finally, the Commission identified a product market for electricity retail to metered and non-metered customers because of different products and pricing conditions. The latter are comprised within a geographic market respectively national and national/regional.

The Commission found that the Merger would have reduced the competitive constraints on DONG in the Danish market for gas storage and gas flexibility. Prices for storage would have become higher for other players in the industry since the merging entities would have gained access to flexible facilities, which would have replaced storage. Moreover the Commission claimed that the concentration would have reduced the competitive constraints on DONG in the Danish wholesale market because E2 and ELSAM are considered as potential competitors. This would have also leaded to a possible customer foreclosure, creating an obstacle for potential entrants. The Commission also stated that the merger would have improved the dominant position of DONG in the Danish markets for supplies to industrial customers and decentralised CHPs because it would have created barriers to entry related to gas storage and eliminated

potential competitors such as E2 and ELSAM. The notified concentration would have reduced competitive constraints in the markets for the supply of gas to households and small business customers. DONG would have jointly held a dominant position in a very transparent market, increasing entry barriers due to storage limitations, reducing potential competition from KE and NESA which had easy access to gas.

Concerning the electricity market, no concerns were found in the defined markets for electricity wholesale, ancillary services, financial derivatives, retail supply to business customers and small customers.

Following the possible impediment to effective competition encountered in the analysis of the Commission, Dong committed to divest facilities in the storage market and pledged to attain a gas release programme with the aim of boosting liquidity and flexibility, providing availability of gas to third parties in the wholesale market. The commitments were considered sufficient to remove harm to competition created by the merger in the storage/flexibility market, wholesale market for natural gas and on natural gas retail markets. The remedies had the role of avoiding the creation of entry barriers and the elimination of potential competition.

3.2. Data and descriptive analysis

The following table discloses and describes all the variables that have been used to construct the final dataset of the analysis. It is possible to notice that 68 observations were provided and that three dummy variables were created. Each variable will be described in detail in the next sections together with the source.

Table 1: Descriptive statistics of the consumer variables

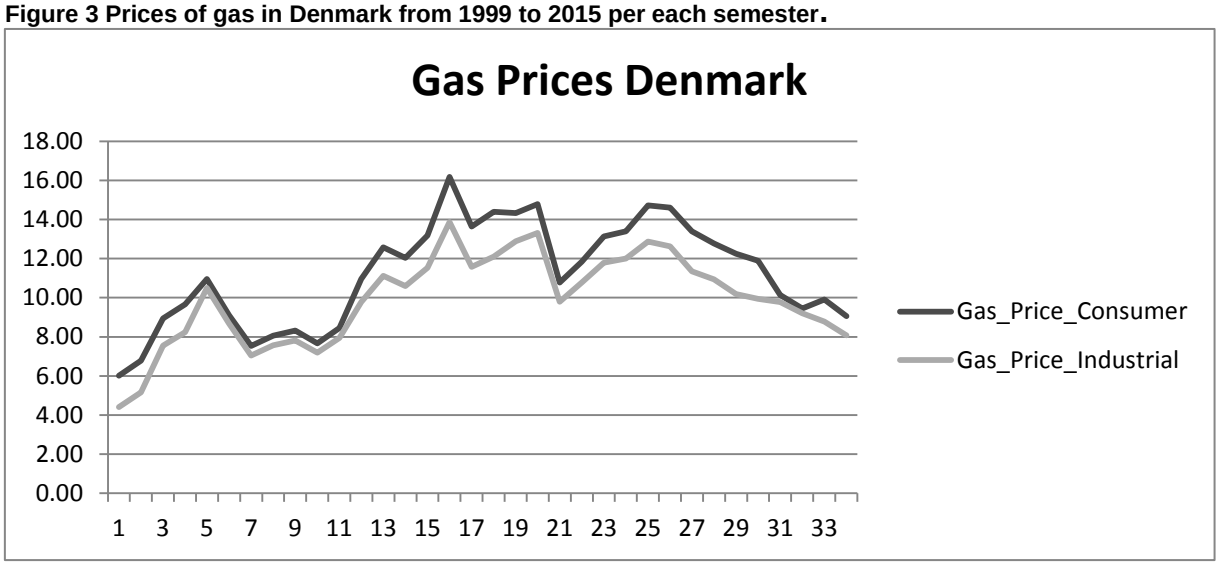
Variables	Obs	Mean	Std. Dev.	Min	Max
Year	68	0.470588	0.5028453	0	1
Treat	68	0.5	0.5037175	0	1
Diff_Dummy	68	0.235294	0.4273363	0	1
Year_Number	68	17.5	9.883652	1	34
Gas_Price_Consumer	68	11.29279	2.758463	6.01	17.69

Gas_Price_Industrial	68	8.742941	2.654476	3.65	13.87
Electricity_Price_Consumer	68	0.112941	0.0318606	0.07	0.21
Solid_Cons	68	19600.89	16198.98	1726.6	41237.2
Petroleum_Cons	68	42234.64	34854.23	6443.4	84463.4
Gas_Cons	68	41386.49	38204.85	2804	87751.5
Renewable_Cons	68	4577.968	3087.313	1628.2	14740.1
Electrical_Cons	68	412.9059	597.1546	-734.7	1800.3

3.2.1. Dependent Variable

The dependent variable in the analysis was obtained from Eurostat, the Statistical Office of the European Union. A database was created extracting the price of the natural gas both for households and for industrial consumers (which might also include data from other areas like offices, restaurants, services, transport). The end users were originally classified by bands of consumption, but for the purpose of the analysis only the middle band are considered. Moreover, different levels of taxation were available. In order to eliminate any effect which might not be related to the merger, the prices excluding all levies and taxes were extracted. Taxes and levies should indeed be considered as a country specific factor which would be captured in the regression and would hide the impact of the concentration. The unit of measurement for the different variables is the same, namely gigajoules. The currency used is the Euro. When prices are calculated and presented in Euros, the average exchange rates of the two quarters of the appropriate semester were taken as a reference. It is important to mention that two different methodologies have been used by the office: one until 2007 and another one starting from 2007. The main differences are related to the use of bands of customers instead of the use of typical standard markets and to the averaging over six months instead of fixed prices on the first of January. The prices range from 1999 to 2015 which should be at a time interval wide enough to capture the effects of the treatment compared to the scenario before the concentration.

Figure 3 Prices of gas in Denmark from 1999 to 2015 per each semester.

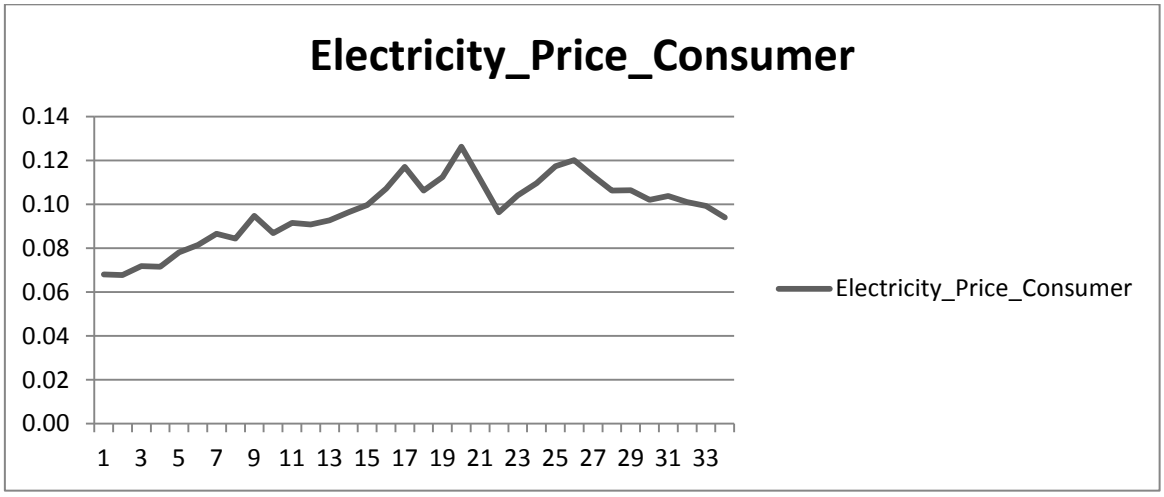


The graph above shows how gas prices for the consumers and industrial end users evolved from 1999 to 2015. Each observation is a semester of the year. There has been a peak that coincided with the financial crisis of 2006 – 2007 (observation number 17) and the debt crisis of 2011 (observation number 25) in Europe.

3.2.2. Control Variables

The control variables are obtained from Eurostat, the Statistical Office of the European Union. The first variable that was extracted is the price of electricity for consumers, which has been used extensively in the literature as a control variable in order to complete the DiD model (Wilkinson, Duso et aliud, 2016). The consumption band is DC, which indicates a range of 2 500 kWh < Consumption < 5 000 kWh. The unit of measure is Kilowatt-hour. Taxes and levies are excluded as in the previous section. The Euro is the currency used for the purpose of this analysis. It is important to notice that as in the previous case, when prices are calculated and presented in Euros, the average exchange rates of the two quarters of the appropriate semester are taken as a reference.

Figure 4 Electricity Prices in Denmark from 1999 to 2015 per each semester



From the graph above it would seem that the price of electricity follows a similar path to the price of gas. This may be caused by the fact that those are highly correlated and that gas is used as an input in order to calculate the price of electricity.

Moreover other variables have been taken into account from the demand and supply side in order to improve the model. A similar approach has been taken by the Commission (Wilkinson, Duso et aliud, 2016). The gross domestic consumption of other sources of energy has been extracted from 1999 to 2015. The gross inland consumption of solid fuels, petroleum products, natural gas, renewable energies and electrical energy was obtained. The unit of measure is the same for all the control variables and it is thousands of tonnes of oil equivalent.

4. Model, methodology and results for the merger DONG/Elsam/E2

In this chapter the choice of model and the methodology used for the purpose of this analysis will be discussed. The results of the model will be also disclosed in the last part of the chapter.

4.1 Model Choice

The empirical model has the aim of identifying the effects of the merger in Denmark on the prices of natural gas for consumers. A difference in difference (DiD) is estimated in order to compare the effects on the treated country Denmark with a different country, namely the UK.

$$PriceGas_{it} = \beta treat_i + \gamma years_j + \delta treat_i * years_j + \epsilon_1 consump_{it} + \epsilon_2 PriceElc_{it} + u_{it}$$

The dependent variable PriceGas is the price of gas in country i at time t. The control variables are related to the factors that can affect supply such as the consumption of sources of energy in country i over time t.

The methodology has the goal of comparing the prices of gas in country Denmark, which is the treated country, and the control country, which will be the UK. The choice of the control country will be discussed further. The dummy treat is equal to one in the case of the treated gas prices.

$$\text{Treat} = \begin{cases} 0 & if \quad country = UK \\ 1 & if \quad country = Denmark \end{cases}$$

The dummy variable years indicates the semesters in which the treatment took place and is equal to one for the semesters after the treatment started i.e. after the first semester of 2007.

$$\text{Years} = \begin{cases} 0 & if \quad year < first\ semester\ of\ 2007 \\ 1 & if \quad year \geq second\ semester\ of\ 2007 \end{cases}$$

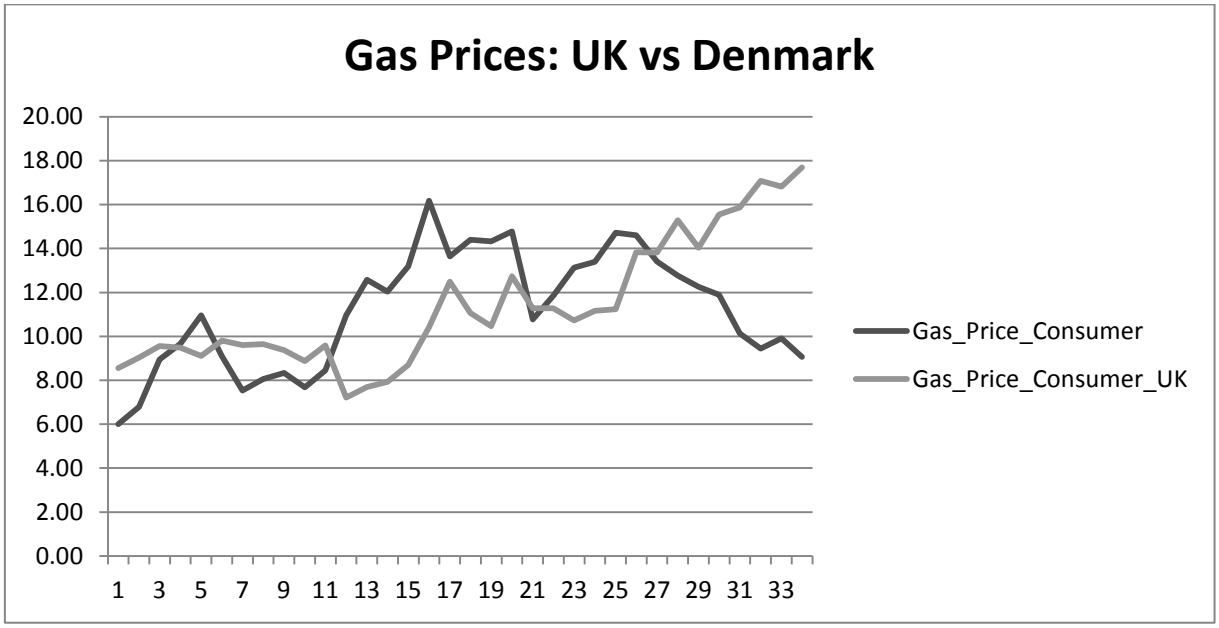
4.2 Control group choice

The control group chosen for the identification is extremely important for the purpose of the analysis. The control group should explain what would have happened to the treated country if the treatment hadn't taken place.

The choice of the control group is difficult because of several reasons. There is a lack of available data for some countries that don't have a time interval wide enough to perform an empirical analysis. Secondly, countries have specific characteristics such as a different policy and regulation in place for the energy sector and prices can be regulated. Third, mergers in the energy sector have been cleared by the Commission in almost every country in Europe, with more than 300 cases in the last 12 years (Commission Report, 2015). All European countries are more and more interconnected and the price change in one country can affect the others, especially if it is a close country.

Given all these issues in the choice of the control group, the UK appeared to be the most appropriate since it is less connected to Denmark than other Nordic countries but at the same time it has a developed technology compared to the other possible control groups, which makes it similar to Denmark. Finally and most importantly the UK where not found to be part of the geographic market that the Commission considered to be affected in the first place.

Figure 5 Time series of gas prices in Denmark and the UK from 1999 to 2005 per each semester



The prices before the merger seem to have on average a similar value for the UK and for Denmark, which would make the UK a good control group. After the merger takes place, there is a clear change in the trend of the two countries. The price in the UK increases drastically compared to the Danish scenario.

4.3 Treatment period choice

In order to study the effects of the merger it is essential to analyse the key moments of the decision. Since the merger has been approved with remedies, the analysis should consider the moment in which the remedies were finalized as the starting moment of the treatment for the Danish market. The most important milestones in the decision are therefore:

- The decision on the concentration: 14 March 2006
- The divestiture of gas storage facility in Lille Torup in Jutland: 1 May 2007
- The gas release program: from the year 2006 to 2011

Even though the markets may be sensible to the announcement of the decision of the Commission, especially in the wholesale market, it is unlikely that this small effect could be passed on to the downstream market. Moreover, the frequency of the data is not high enough to show that effect. Therefore it is not considered in the analysis.

The first semester of 2007 is chosen as the start of the treatment period because it is the final moment in which all remedies took place and the merger can be considered concluded according to the Commission decision. The gas release program starts before the divestiture.

4.4 Estimation of the Model

We proceed first with the estimation of the model that predicts the prices of gas for consumer and then with the estimation of the model that predicts the prices of gas for industrial end users.

4.4.1 Consumers Model estimation

The first estimation of the model had several statistically insignificant values (see

Annex 1: Consumer model estimation with all the control variables (Stata output)). Therefore the non-significant values were dropped in order to arrive to the second specification of the model which is shown in Table 2: Final Model estimation.

Table 2: Final Model estimation for Consumers

Variables	Consumers_Model
year	-0.024
	(0.959)
treat	-2.071
	(0.000)***
diff_dummy	**-2.382**
	(0.002)* **
electricity_price_consumer	110.212
	(0.000)***
_cons	0.453
	(0.621)
R-squared	0.7979
Observations	68

The table above shows the result of the consumer prices model estimated. The values shown in brackets under each coefficient are the p-values related to each one of the coefficients. Each p-value is given one, two or three stars depending on the level of significance of the result. Respectively, one star indicates a significance level of 1% or higher, two stars represent a significance level between 1% and 5%, three stars represent a significance level between 5% and 10%. Unfortunately not all the initially collected variables resulted in being statistically significant and had therefore to be dropped to get to the final models.

The control variables comprised in this model are more statistically significant than in the previous. The diff_dummy is -2.4 and is stastically significant with a p-value of 0.002. The coefficient hasn't changed by reducing the control variables, which gives a good signal that there is no omitted variable bias. At this point the misspecification testing is performed (see Annex 2: Final Consumer model estimated and tests (Stata output)). The test shows that the model is not well

specified. It is nevertheless unsuccessful to model the other non linearities given the control variables. The model is the best linear approximation. Applying the normality test to the residuals from the regression, it is possible to notice that the Jarque-Bera test yields a t-statistic of 0.2166 with a p-value of 0.8974. The Doornik-Hansen version, which is more suitable for small samples, yields a statistic of 1.3301 with a p-value of 0.5142. We see that normality is not rejected. Furthermore the R-squared is almost 0.8, which is high and indicates that the model is well fitted.

4.4.2 Industrial end users Model Estimation

Again, the first estimation of the industrial end users model has several statistically insignificant values (see Annex 3: Industrial end users Model Estimation with all the control variables and relative tests (Stata Output)). Therefore we drop the non-significant values and arrive to the second specification of the model, performing the white's test for testing homoscedasticity.

Table 3: Final Model estimation for industrial users

Variables	Industrial_Users_Model
year	0.331
	(0.547)
treat	-3.752
	(0.000)***
diff_dummy	**-2.308**
	(0.014)**
electricity_price_consumer	81.864
	(0.000)***
_cons	1.760
	(0.170)
R-squared	0.671
Observations	68

The table above shows the results obtained in the estimation of model on industrial users prices. Again, the coefficients and the p-values related to each coefficient are presented with a significance level rating provided by the number of

stars. The model is regressed with the robust option since the White-s test showed signs of heteroscedasticity given that the null hypothesis of homoscedasticity is rejected (see Annex 3: Final model estimated for industrial users and relative tests (stata output)). The control variables comprised in this model are more statistically significant than in the other. The diff_dummy coefficient is -2.3 and is statistically significant with a p-value of 0,014. The R-squared is very high in this case as well. At this point the misspecification testing is performed. The test shows that the model is well specified. Applying the normality test to the residuals from the regression, we see that the residuals of the model follow a normal distribution.

4.4.3 Results

Presented above are the results of the two models estimated for the first part of this study. The most important coefficient is the one related to diff_dummy. It represents the coefficient linked to year*treat variable. In both models the coefficient is significant. In the case of the consumer price it is significant even at the 1% significance level. In the case of the industrial end users it is significant at the 5% significance level. Nevertheless the second model performs better than the first one in terms of misspecification testing for what concerns all the tests performed.

In both models the coefficient related to the diff_dummy is negative and provides evidence that the effect of the merger was a decrease in prices in Denmark compared to the UK, the control country. The negative coefficient linked to the treat variable indicates that the gas prices in Denmark were lower on average than in the UK. This result is also statistically significant and valid for both models. The coefficient related to year shows evidence that the prices in both models were not significantly different on average after the merger with respect to before the merger. The coefficient linked to the control variable price of electricity for consumers shows evidence of a positive impact of electricity price on gas prices.

5. Descriptive statistics and case study summary of the merger SANOFI-SYNTHELABO/ AVENTIS

The second part of this study will focus on the analysis of a merger case from the pharmaceuticals sector, which happened in the past and for which an ex post evaluation can be performed.

The analysed merger, namely M.3354 SANOFI-SYNTHELABO / AVENTIS, was obtained from Directorate General for Competition by using the merger research tool. It is classified under the NACE code C.21.20 which stands for manufacture of pharmaceutical preparations. The decision was published the 26th of April 2004 with conditions and obligations.

5.1. Review of the case

At the beginning of the year 2004, Aventis agreed to be acquired by Sanofi-Synthelabo through a hostile takeover. This concentration generated the world third largest medicine producer at that time after Pfizer and GlaxoSmithKline. According to an article published by the BBC News (2004), the merger was thought to have a remarkable impact on the French market, therefore the French Prime Minister at that time commented on the case saying that it would have maintained jobs and decision centers in France.

The main reason why this merger was chosen is that it is one of the biggest deals, in terms of bid, which took place in the pharmaceuticals sector in Europe during a period between the years 2000 and 2010 (Statista Statistics Portal, 2017), a time range for which data was available. Moreover, the deal took place between two French inventors, which is essential for the purpose of the creation of the model. Finally the pharmaceuticals sector is a high technology business for which patenting activity is essential and can be a good proxy of innovation (Dernis, Guellec, 2001).

According to the Commission decision M.3354 SANOFI-SYNTHELABO / AVENTIS, the parties involved in the decision were Sanofi-Synthélabo and Aventis. The two companies were both based in France: the first one in Paris and the second one in Strasbourg. Both were listed in the stock market. Sanofi was active in the research, development, production and commercialization of

pharmaceutical products in sectors such as vaccines, animal health care, therapeutic proteins and chemistry, fabrication of active pharmaceutical principles. The same being true at the time for Aventis, which was present in the sectors of animal healthcare, human vaccines and chemistry.

For the purpose of this analysis it is important to state that the major competition concerns identified by the Commission were related to areas of thrombosis, colorectal cancer and insomnia. But the two parties were able to divest and offer behavioral remedies which allowed the Commission to clear the merger. In some activities the two companies overlapped and could therefore cause the creation of a dominant position which would have been detrimental for competition and final customers and patients.

The Commission identified relevant markets and accepted related remedies which were submitted by the parties. The Delagrange product belonging to the vitamin B12 (A11F) relevant market in France was divested. Positive inotropic agents (C1F) relevant market also raised an issue in the United Kingdom and Belgium but the drug Perfan was pledged to be sold or licensed. Cerebral and peripheral vasotherapeutics (C4A) relevant market in Ireland was also divested or licensed for what concerned Hexopal drugs. The drug Lioton 1000 was divested in order to overcome competition concerns in the topical varicose therapy (C5B) relevant market in Italy. The French relevant markets macrolides and similar types (J1F) and glycopeptide antibiotics (J1X1) were protected from competition concerns through the divestiture or licensing of respectively Naxy and Vancomycine Dakota. Sanofi offered to licence or grant Plaquinol, Adalgur N and Coltramyl drugs in order to settle issues related to the specific anti-rheumatics (M1C) and muscle relaxants (M3B) relevant product markets in Portugal. Imovane was sold or licensed to settle issues concerning Hypnotics and sedatives (N5B) relevant markets in Greece, Ireland, Luxembourg and Sweden. Moreover the parties pledged to divest Fraxiparin and Arixtra in the heparins and heparinoids market in Germany, Austria, Belgium, Spain, Finland, France, Italy, Luxembourg, the Netherlands, Portugal and the United Kingdom, as well as divesting an entire related French plant to GlaxoSmithKline. Finally the treatment of colorectal cancer was not considered to raise concerns for competition in France, Germany, Italy,

the Netherlands, Spain, Sweden and the United Kingdom, as long as the newly merged entity would have sold or licensed all the activities related to Campto drug.

The Commission didn't perform an analysis which took into account dynamic efficiencies and the effect of the merger on innovation. Nevertheless this decision was one of the most adequate for the purpose of this study because of its likely impact on the R&D pipeline. According to an article published by the 'Nature Reviews Drug Discovery' (Frantz, 2004) the merger between Aventis and Sanofi-Synthélabo would have been a good R&D merger. The article reviews several opinions of analysts that analyzed the pipelines of the company and came to the conclusion that the two entities would have produced a complementary new company (Frantz, 2004). Pipelines had few overlaps and the late stage projects of Sanofi would be included perfectly in Aventis late stage poorer pipeline. Moreover the main drugs that created overlaps were dealt by the remedies offered to the Commission by the parties. According to analysts' opinions gathered in the article, future R&D and innovation would have depended also upon the ability of the two companies to merge the professional talents and different working cultures. For example Sanofi was characterized by smaller research teams focused on particular areas, whereas Aventis had a broad network thanks to which all experts were able and even encouraged to contribute to projects other than their owns (Frantz, 2004).

5.2. Data and Descriptive Analysis

The following table lists and describes all the variables that have been used to create the final dataset, which served as an input for the estimation of the model and for the purpose of the analysis.

Table 4: Descriptive statistics France and Italy

Variables_Italy_Scenario	Obs	Mean	Std.Dev.	Min	Max
Year	38	2004	5.550749	1995	2013
Year_Dummy	38	0.5263158	0.5060094	0	1
Treat	38	0.5	0.5067117	0	1
Diff_Dummy	38	0.2631579	0.4462583	0	1
Patent_Applications	38	358.9373	125.9061	145.6524	579.5066
GERD	38	29945.67	13174.72	11858.24	58406.06

Researchers	38	142510.2	66289.55	65098	266222
R&D_Personnel	38	269272.4	95025.78	141789	418141
BERD_Tot	38	15354.41	8305.586	4479.02	30708.07

Table 5: Descriptive statistics France and Denmark

Variables_Denmark_Scenario	Obs	Mean	Std. Dev.	Min	Max
Year	38	2004	5.550749	1995	2013
Year_Dummy	38	0.526316	0.5060094	0	1
Treat	38	0.5	0.5067117	0	1
Diff_Dummy	38	0.263158	0.4462583	0	1
Patent_Applications	38	298.4176	179.2265	70.7628	579.5066
GERD	38	22575.58	19390.87	2120.288	58406.06
Researchers	38	114256.5	92249.29	15954	266222
R&D_Personnel	38	200258.8	159704.3	30212	418141
BERD_Tot	38	13106.58	10331.04	1452.102	30708.07

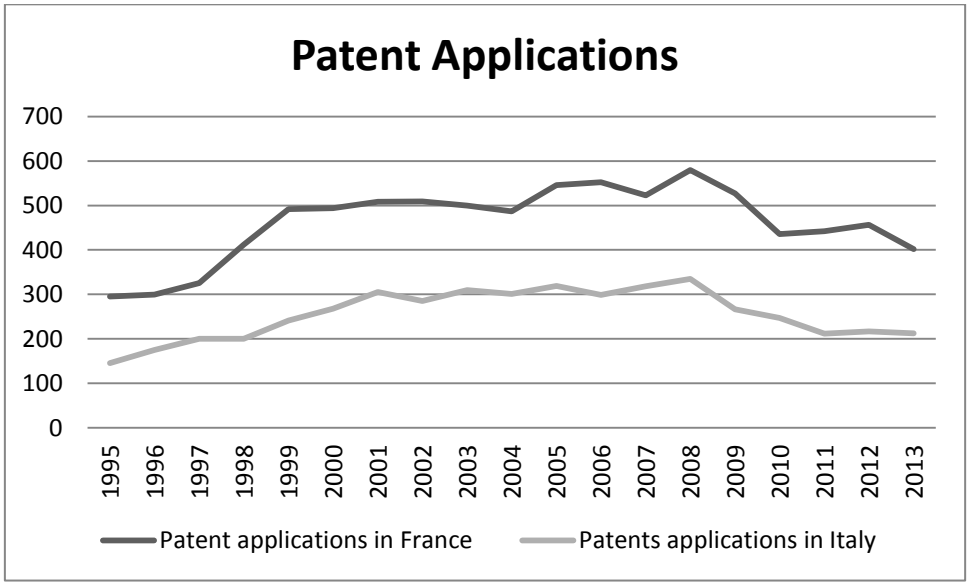
The dataset is composed of 38 observations which range on period that goes from 1995 to 2013. All the variables were collected from an electronic publication of the Economic Analysis and Statistics Division of the OECD Secretariat. The data of the publication is selected from the OECD Scientific Technology Indicators database. The OECD collects data on the 35 Member countries and has started collecting data also on some of the non-member economies. The data is based on retrospective surveys and national forecasts when those are available. Even if this study is not based on variables which measure the output of Innovating activity of a country, some of them could be a good proxy indicator of the how the country performs in terms of scientific research and innovation according to the Economic Analysis and Statistics Division of the OECD Secretariat.

5.2.1. Dependent Variable

As just mentioned above, the dependent variable of the analysis was obtained from the OECD database. The database was created by extracting the number of

patent applications filed to EPO's Worldwide Statistical Patent Database (PATSTAT, Autumn 2016) from 1995 to 2013. According to the Frascati Manual (OECD, 2015) patents are counted as the number of applications which were filed to European Patent Office, which is an important information for the purpose of assessing whether a certain country has performed well from an innovative point of view. More in particular the choice of the country of residence of the inventor is fundamental. The priority date is taken as the reference date as it is the best way to estimate the invention date. Indeed the priority date is the closest date to the invention, the first filing worldwide, and it doesn't produce a bias between residents and foreigners (OECD, 2015). Inventors first submit their application in the country of residence office and, after usually at least one year, file the application in foreign offices to seek protection. For what concerns the country selection, inventors' country selection is the best variable for tracking the innovative performance of researchers and laboratories of a certain country (OECD, 2015). Patents were extracted only for the pharmaceuticals sector which is the one that is impacted by the merger. This sector is selected according to the International Patent Classification code that is provided in each patent and the industry is based on the International Standard Industrial Classification, Revision 4 (ISIC Rev.4), in which the two companies are operating. The OECD Manual (2015) reminds that patents are a good proxy of innovation production in relation to the geographical area and the technology. Patents can give a good indication of the outcomes of R&D, as has been seen in several studies. Patents can therefore be seen as an output of the inventions and R&D. Patents have positive aspects from a statistical perspective: they are strongly related to invention, it is a good source of data, information on applicant, technology and geographic area are easily obtained, etc. Nevertheless there are also some negative statistical implications that need to be recalled at the moment of the analysis of patents applications: many patents have no industrial application and don't account for innovation but just for inventions, some inventions may not be patented because of industrial secrecy reasons for example, different countries and industries apply different norms on patenting. All this aspects need to be considered when conducting the research and at the moment of interpreting the results.

Table 6: Patent applications in France and in Italy



From the Patent Applications graph it is possible to notice that compared to the Italian market, there has been a slight increase in the patents applications in France in the year in which the merger between Sanofi-Synthélabo and Aventis was performed. Moreover, both countries seem to suffer from the 2007 financial crisis, because of a reduction in the total number of patent applications in both countries. Overall, it is clear that there has been an increase in the production of patents in both countries from 1995 to 2013.

5.2.2. Independent Variables

The independent variables that are used for the purpose of this study were also extracted from the OECD database, as mentioned above. The main indicators available for the selected time frame and countries of reference were the Gross Domestic Expenditure on R&D, R&D personnel, R&D expenditure in the business and enterprises sector and the full time researchers.

The Gross domestic expenditure on Research and Development is the total domestic expenditure in R&D that was performed in a certain country within a given timeframe, which is one year in this case. The R&D expenditure in the Business Enterprise Sector encompasses both private and public owned entities which are classified according to their main activity. Nevertheless it was not

possible to obtain the expenditure related exclusively to the pharmaceuticals field. For this reason the total R&D costs have been extracted and used for the purpose of this analysis. The unit of measure for the number of R&D personnel is the full-time equivalent on Research and Development. Again only the total of the researchers and not only the number related to the pharmaceuticals sector was available. So the same approach was used in the case of full time researchers.

The time period taken into account starts in 1995 and ends in 2013. The currency of reference for the Gross Domestic Expenditure on R&D is the United States Dollar, which has been converted using purchasing power parity series taken from the OECD National Accounts Division. The purchasing power parity compared the United States prices with those of the other countries. It is also fundamental to mention that the R&D statistics refer to those activities which are carried out domestically for activities related to R&D. This means that for example, performers abroad are not taken into account. For what concerns the Business Enterprise Expenditure on R&D the currency of reference is the Euro. The unit of measurement is millions of Euros.

On the comparability of observations over time it is worth mentioning that new methodologies have been implemented throughout the years. In the year 2000 there was a break in the series, given a change in public sector quality of data, which could have brought to a slightly higher level than expected. There has been a revision in 1997 of the methodology to assess R&D expenditure and personnel. Finally, the Business Enterprises sector has undergone several adjustments in the methodology from 2001 to 2007 for reasons related to the definition of the population, the quality of the source and the new methodologies implementations.

Table 7: Business Expenditure on R&D in France and Italy

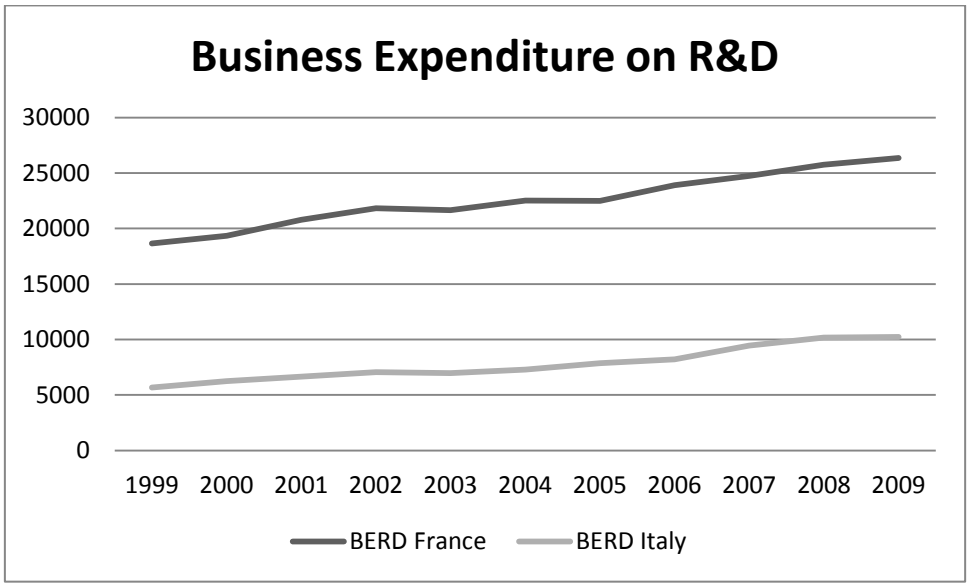
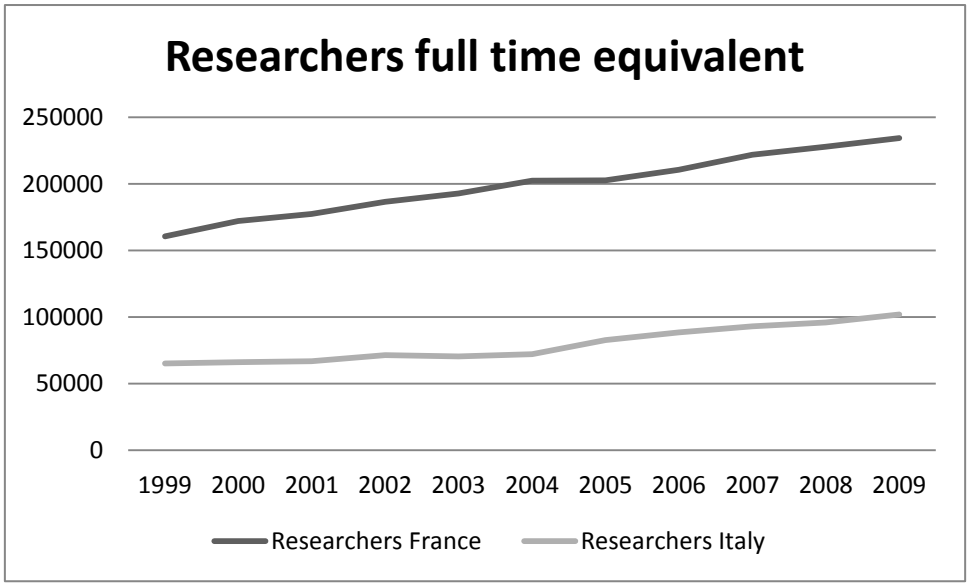


Table 8: Researchers full time equivalent in France and in Italy



The above graphs show that the independent variables of the dataset are undergoing a continuous growth. That is true both for business expenditure on research and development and for researchers full time equivalent. France maintains almost three times the researchers and BERD of Italy.

6. Model, methodology and results of the merger SANOFI-SYNTHELABO/ AVENTIS

6.1. Choice of the model

The empirical model has the ultimate objective of identifying the effect of the merger in France on the patenting activity in the pharmaceutical sector. The model chosen is a difference in difference (DiD), which compares the effect that the treatment variable has had on the treated country France compared to a control country, which is in this case Italy. In the second part of the study a placebo test will consider Denmark as a control country.

$$patent\_applications_{it} = \beta treat_i + \gamma year\_dummy_j + \delta diff\_dummy_{it} + \epsilon_1 researchers_{it} + \epsilon_2 berd\_tot_{it} + u_{it}$$

The dependent variable patent_applications is the number of applications filed in country i at time t. The control variables are the number of researchers at year t in country i and the business expenditure on R&D in country i at time t. The choice of the control group will be discussed further on. The dummy treat is equal to one in the case of the treated patent applications (France) and zero otherwise (Italy).

$$\text{Treat} = \begin{cases} 0 & if \quad country = Italy \\ 1 & if \quad country = France \end{cases}$$

The dummy variable year_dummy indicates the years after which the merger took place and is therefore equal to one when the treatment was in action, i.e. starting from 2004 onwards.

$$\text{Year\_dummy} = \begin{cases} 0 & if \quad year < 2004 \\ 1 & if \quad year \geq 2004 \end{cases}$$

The variable diff_dummy is the product of the variables treat and year_dummy.

6.2. Control group choice

The choice of the control group is one of the most important aspects of the analysis since it identifies the counterfactual scenario that could have taken place in the case in which the treatment had not been provided to the studied subject.

In this case it appears clear that it is mandatory to exclude Germany and the USA as control groups. According to the decision of the Commission, a part of the acquired company was owned by German and by USA firms as well, which might have been affected by the merger and might therefore not be suitable for the purpose of this study.

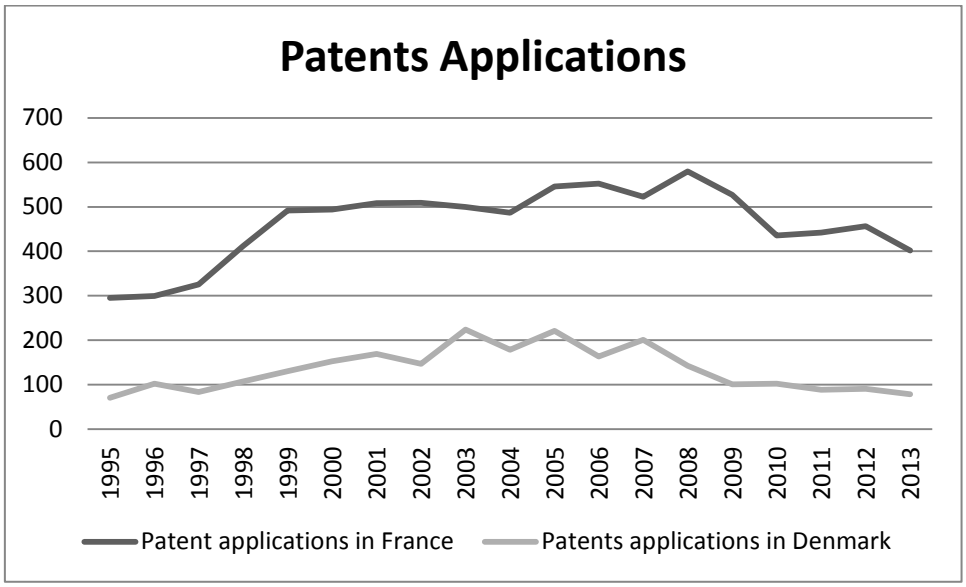
Secondly, not all the countries could be presented in the dataset because of a lack of available data for the purpose of this analysis. Third, there have been mergers in the pharmaceuticals sector cleared by the Commission in almost every EU member state, which makes it really hard to have a perfectly clean counterfactual scenario of how competition would have been in absence of the treatment.

Nevertheless the merger case between Sanofi-Synthélabo/ Aventis is one of the biggest mergers that took place not just in the European pharmaceutical sector, but in all Europe even across all the other industries, within the period taken into account. Moreover the merger has taken place between two firms based in France, therefore the applications produced by those firms will reflect the competitiveness of the French market and only in a later stage will be filed in other countries such as Italy or Denmark. Therefore the innovation activity is captured by the patents application dependent variable of each country.

Given all this limitations and previous remarks, the control group chosen for the main study is Italy. Moreover Denmark is considered for the purpose of a placebo test. Italy is among the potential countries, the one remaining country which has the patenting activity most similar to France previous the merger, in terms of number of patents applications. The trend between the two countries then shows a different path after the treatment starts. Finally Denmark was not found by the Commission to be part of the relevant markets for which competition concerns were raised by the merger. Therefore it is less likely than in the Italian case that

the merger would have impacted the innovative activity of those firms present in Denmark, even indirectly through the marketing and sales of pharmaceuticals.

Table 9: Patents applications in France and Italy



As it can be shown by the graph, Denmark as well has a similar trend before the merger, which would make of it a suitable counterfactual scenario.

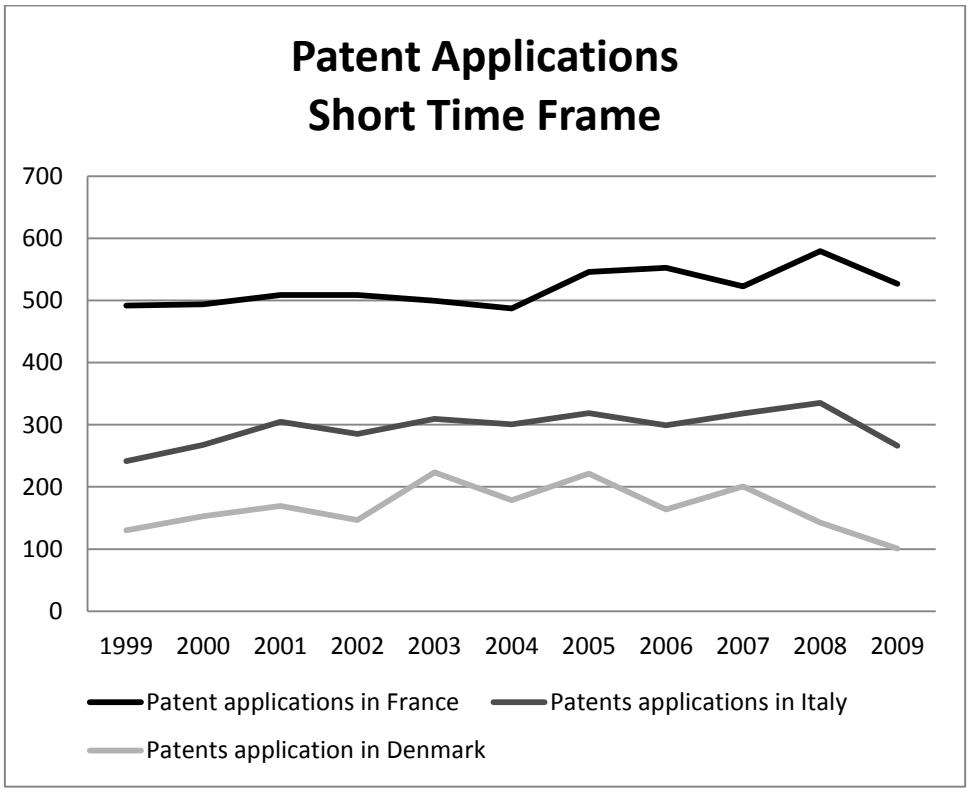
6.3. Treatment period choice

In order to assess the impact of the merger on innovation it is important to take into account when the merger was performed. The decision was released in April 2004, therefore the assumption is made that the merger had the time to be finalized in that very same year. Moreover, for the purpose of the analysis two different time frames were taken:

- Long Time Frame (i.e. 18 years): from 1995 to 2013
- Short Time Frame (i.e. 10 years): from 1999 to 2009

From the graph below it is possible to notice that the change in the patenting activity of France compared to other scenarios is even more remarkable in the shorter time frame. There appears to be an increase compared both to Italy and Denmark, the latter being more volatile.

Table 10: Patent Applications France, Italy and Denmark



The distinction between the two time frames was performed in order to obtain more information on the effects of the merger on innovation. Each study can be interpreted separately and a confirmation from both time periods cannot harm the research. It is important to include both a Short and a Long Time Frame: the impact on R&D can be stronger in the long term, given that the entire knowledge acquired by the buyer may need time to be completely assimilated. Therefore synergies may be noticed both in the short term but also in the medium and long term.

Finally, the numerous remedies that were accepted by the commission were not clearly defined in terms of the time frame and therefore were not taken into account for the choice of the treatment period.

6.4. Estimation of the model

The main model estimated will be between Italy and France for the long time frame. It would be the most representative given the several limitations, remarks and assumptions previously mentioned. Nevertheless, one placebo test will be

produced for Denmark in order to confirm the results obtained in the previous scenario. Each model will be estimated both for the short and for the long time frame, in order to provide more information in the assessment.

6.4.1. Model

Table 11: Models estimated for each scenario and p-values relative each coefficient

	Countervailing Scenarios			
Variables	**Italy_Long**	**Italy_Short**	**Denmark_Long**	**Denmark_Short**
year_dummy	29.675	-4.297	-1.730	-0.085
	(0.288)	(0.854)	(0.945)	(0.997)
treat	181.504	283.752	466.319	300.594
	(0.055)*	(0.055)*	(0.005)***	(0.010)***
diff_dummy	**102.102**	**41.647**	**149.736**	**34.177**
	(0.033)**	**(0.047)****	**(0.056)***	**(0.311)**
researchers	-0.006	-0.004	-0.009	-0.001
	(0.000)***	(0.003)***	(0.027)**	(0.513)
berd_tot	0.048	0.027	0.069	0.015
	(0.000)***	(0.065)*	(0.025)**	(0.510)
year		9.107		
		(0.285)		
_cons	392.633	-17,844.9	143.862	153.009
	(0.000)***	(0.293)	(0.000)***	(0.000)***
R-squared	0.808	0.975	0.895	0.973
Observations	38	22	38	22

The above table summarizes all the results that were obtained for the different countervailing scenarios. The values shown in brackets under each coefficient are the p-values related to each one of the coefficients. Each p-value is given one, two or three stars depending on the level of significance of the result. Respectively, one star indicates a significance level of 1% or higher, two stars represent a

significance level between 1% and 5%, three stars represent a significance level between 5% and 10%. Unfortunately not all the initially collected variables resulted in being statistically significant and had therefore to be dropped to get to the final models.

It is clear that the results obtained all confirm that the merger has had a positive impact on the production of patents applications in France compared to the other controlling scenarios.

6.5. Results

In the first scenario, namely Italy_Long (see: Annex 5: Final Model Italy long time frame and relative tests (stata output)), the coefficient related to the diff_dummy is 102.102 with a significance level within the 5% level with a p-value of 0.033. Therefore it can be concluded that the merger has had a positive effect on the French market, causing an increase of 102.102 number of patents on average compared to the control group, Italy. The time frame is from the year 1995 to the year 2013. The R-squared is also quite high, namely 0.808, meaning that the sample observations are close to the estimation line. Concerning the characteristics of the model, the tests performed and provided in the appendix show that the model had heteroscedasticity, which was corrected by running the model with robust standard errors. Finally, the misspecification tests were all passed.

In the second scenario, namely Italy_Short (see Annex 6: Final Model Italy Shorter Time frame and relative tests (stata output)), the time frame is reduced to 1999 to 2009. The coefficient related to the diff_dummy is lower than in the previous case, with a value of 41.647 and the same significance level within the 5% level but a p-value slightly larger. This regression confirms the results obtained in the main model and the merger still has a positive effect on the French market, causing an increase of 41.647 on average compared to the control group, Italy. The R-squared is also even greater than the previous case, namely 0.975, meaning that the sample observations are very close to the estimation line. The model was run with robust standard errors. Finally, the misspecification tests were all passed in this case as well.

The third scenario, Denmark_Long (see Annex 7: Final model estimated for the placebo Denmark counterfactual scenario in the long time frame and relative tests (stata output)), is a placebo test that is run for the long time frame from 1995 to 2013. Diff_dummy, coefficient of interest for this research, is positive and as high as 149.736, with a significance level within the 10% level and a p-value of 0.056. This regression again confirms the results obtained in the previous models. The 0.895 R-squared is still high. Misspecification tests were run and heteroscedasticity was found. After running the model with robust standard errors, the other misspecification tests, which are provided in the appendix, didn't show any particular issue.

The fourth and last scenario is Denmark_Short (see Annex 8: Final model estimated for the placebo Denmark counterfactual scenario in the short time frame (stata output)). Unfortunately the coefficient obtained from the diff_dummy variable is not statistically significant given its p-value of 0.311. Nevertheless the positive coefficient obtained shows a positive effect of the merger, which can be interpreted as a confirmation, even if not entirely reliable, of all the previous results.

7. Conclusions

This study provides significant empirical results on the ex post evaluation of two merger cases that were cleared by the European Commission with remedies.

According to the results of the first part of this study the decision of the Commission on the case DONG/ELSAM/E2 has had a negative impact on gas prices both for consumers and industrial end users in Denmark compared to the UK, starting from the first semester of year 2007.

This study may therefore provide evidence that the remedies imposed on the concentration by the Commission played an important role in increasing competition and passing a surplus to consumers through the reduction of prices in the gas sector. The remedies would have therefore obtained an effect in the downstream market, protecting consumers.

Nevertheless the evidence provided in this study needs to be seen through its limitations which are: i) difficult selection of the control country; ii) lack of data at the wholesale level which was the market that the Commission deemed to be affected mostly by the merger iii) non-accountability of regulation changes and other merger decisions that may have an impact on the study from country to country.

Concerning the second part of the study it is possible to notice that the decision of the Commission on the case Sanofi-Synthèlabo/Aventis has had a positive impact on the production of patent applications in France compared to Italy, both for a long and short time frame, and to Denmark.

This analysis can therefore provide evidence that the merger that the merger cleared by the Commission and all the relative obligations to divest have had a positive impact on innovation in the pharmaceutical sector.

Nevertheless the results of the second part of the study need to be understood without forgetting some of the limitations of this study, namely: i) the drawbacks related to the use of patent applications as a proxy for innovation output; ii) the limited number of control variables that were available for the construction of the

model; iii) the negative aspects linked to the choice of counterfactual scenarios which may not be perfectly comparable with the treated market.

This thesis contributes to the ex post evaluation of mergers literature by providing significant results on two merger cases that were cleared by the Commission with remedies. It confirms that in those two cases the Commission took the right decision to the benefit of competition, prices and innovation.

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Annexes

Annex 1: Consumer model estimation with all the control variables (Stata output)

Source	SS	df	MS
Model	410.730689	9	45.6367432
Residual	99.080072	58	1.7082771
Total	509.810761	67	7.60911583

Number of obs	= 68
F(9, 58)	= 26.72
Prob > F	= 0.0000
R-squared	= 0.8057
Adj R-squared	= 0.7755
Root MSE	= 1.307

gas_price_consumer	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
year	-.026851	.5940047	-0.05	0.964	-1.215881	1.162179
treat	-1.709974	9.078789	-0.19	0.851	-19.88315	16.4632
diff_dummy	-2.509763	1.139877	-2.20	0.032	-4.791475	-.2280524
electricity_price_consumer	120.4883	14.75974	8.16	0.000	90.94347	150.0331
solid_cons	.0000445	.0000761	0.58	0.561	-.0001078	.0001967
petroleum_cons	-.0000595	.000128	-0.46	0.644	-.0003157	.0001967
gas_cons	.0000328	.0000809	0.41	0.687	-.0001291	.0001947
renewable_cons	-.0000564	.0002382	-0.24	0.814	-.0005332	.0004204
electrical_cons	-.0002462	.000569	-0.43	0.667	-.0013852	.0008929
_cons	-.2137648	1.756862	-0.12	0.904	-3.730506	3.302976

Annex 2: Final Consumer model estimated and tests (Stata output)

Source	SS	df	MS
Model	406.787268	4	101.696817
Residual	103.023492	63	1.63529353
Total	509.810761	67	7.60911583

Number of obs	= 68
F(4, 63)	= 62.19
Prob > F	= 0.0000
R-squared	= 0.7979
Adj R-squared	= 0.7851
Root MSE	= 1.2788

gas_price_consumer	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
year	-.0243777	.4748532	-0.05	0.959	-.9732961	.9245406
treat	-2.071135	.4383278	-4.73	0.000	-2.947064	-1.195207
diff_dummy	-2.382047	.7455056	-3.20	0.002	-3.871821	-.8922728
electricity_price_consumer	110.2128	9.676125	11.39	0.000	90.87664	129.549
_cons	.4527476	.9113845	0.50	0.621	-1.368509	2.274004

Ramsey RESET test using powers of the fitted values of gas_price_consumer
Ho: model has no omitted variables
F(3, 60) = 3.52
Prob > F = 0.0202

(n = 68)	D-H	P-value	asy.	P-value
Residuals	1.3301	0.5142	0.2166	0.8974

Annex 3: Industrial end users Model Estimation with all the control variables and relative tests (Stata Output)

Source	SS	df	MS	Number of obs	=	68
				F(10, 57)	=	24.13
Model	412.404953	10	41.2404953	Prob > F	=	0.0000
Residual	97.4058074	57	1.70887381	R-squared	=	0.8089
				Adj R-squared	=	0.7754
Total	509.810761	67	7.60911583	Root MSE	=	1.3072

gas_price_consumer	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
year	-.7345233	.9295791	-0.79	0.433	-2.595973	1.126927
treat	.4152421	9.330762	0.04	0.965	-18.26929	19.09977
diff_dummy	-1.755994	1.371017	-1.28	0.205	-4.501407	.9894199
electricity_price_consumer	121.3337	14.787	8.21	0.000	91.72323	150.9442
solid_cons	.0000122	.0000828	0.15	0.883	-.0001535	.0001779
petroleum_cons	-.0000455	.0001288	-0.35	0.725	-.0003034	.0002125
gas_cons	6.92e-06	.000085	0.08	0.935	-.0001633	.0001772
renewable_cons	-.0002994	.0003421	-0.88	0.385	-.0009844	.0003856
electrical_cons	-.0000561	.0006006	-0.09	0.926	-.0012589	.0011466
year_number	.0568414	.0574259	0.99	0.326	-.058152	.1718348
_cons	-.0669598	1.763417	-0.04	0.970	-3.598141	3.464221

White's test for Ho: homoskedasticity
        against Ha: unrestricted heteroskedasticity

        chi2(8)   =   22.52
        Prob > chi2 =   0.0040

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	22.52	8	0.0040
Skewness	2.65	4	0.6188
Kurtosis	0.23	1	0.6309
Total	25.40	13	0.0204

Annex 3: Final model estimated for industrial users and relative tests (stata output)

Linear regression

Number of obs	=	68
F(4, 63)	=	39.69
Prob > F	=	0.0000
R-squared	=	0.6709
Root MSE	=	1.5704

gas_price_industrial	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year	.3317057	.5483404	0.60	0.547	-.7640652	1.427477
treat	-3.752449	.6284109	-5.97	0.000	-5.008228	-2.49667
diff_dummy	-2.308429	.9171085	-2.52	0.014	-4.141124	-.475734
electricity_price_consumer	81.86358	13.35467	6.13	0.000	55.1764	108.5508
_cons	1.760459	1.26854	1.39	0.170	-.7745167	4.295435

```
Ramsey RESET test using powers of the fitted values of gas_price_industrial
       Ho:  model has no omitted variables
                  F(3, 60) =      1.77
                  Prob > F =      0.1632
```

(n = 68)	D-H	P-value	asy.	P-value
Residuals	0.2169	0.8972	0.3565	0.8367

Annex 4: Model Estimation Italy long first try (stata output)

Source	SS	df	MS		
				Number of obs	= 38
				F(7, 30)	= 20.46
Model	484941.722	7	69277.3888	Prob > F	= 0.0000
Residual	101594.654	30	3386.48845	R-squared	= 0.8268
				Adj R-squared	= 0.7864
Total	586536.375	37	15852.3345	Root MSE	= 58.194

patent_app~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
year_dummy	81.46009	49.82589	1.63	0.113	-20.29795	183.2181
treat	195.9084	250.5059	0.78	0.440	-315.6929	707.5097
diff_dummy	24.12412	65.9098	0.37	0.717	-110.4816	158.7299
researchers	-.0052028	.0020227	-2.57	0.015	-.0093337	-.0010718
berd_tot	.0708063	.0342438	2.07	0.047	.0008712	.1407414
gerd	-.0065949	.0158414	-0.42	0.680	-.0389475	.0257576
rd_personnel	-.0017728	.001304	-1.36	0.184	-.004436	.0008904
_cons	540.8843	117.2675	4.61	0.000	301.392	780.3765

Annex 5: Final Model Italy long time frame and relative tests (stata output)

Linear regression

Number of obs	= 38
F(5, 32)	= 45.86
Prob > F	= 0.0000
R-squared	= 0.8082
Root MSE	= 59.287

patent_app~s	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year_dummy	29.67547	27.47441	1.08	0.288	-26.28806	85.639
treat	181.5044	90.98276	1.99	0.055	-3.821392	366.8302
diff_dummy	102.1023	45.87234	2.23	0.033	8.663389	195.5412
researchers	-.0064305	.0011159	-5.76	0.000	-.0087036	-.0041574
berd_tot	.048812	.0095268	5.12	0.000	.0294066	.0682174
_cons	392.6334	50.42204	7.79	0.000	289.9271	495.3397

Ramsey RESET test using powers of the fitted values of patent_applications
Ho: model has no omitted variables
F(3, 29) = 0.22
Prob > F = 0.8828

(n = 38)	D-H	P-value	asy.	P-value
Residuals	1.5780	0.4543	1.3034	0.5212

Annex 6: Final Model Italy Shorter Time frame and relative tests (stata output)

Linear regression

Number of obs	= 22
F(6, 15)	= 219.28
Prob > F	= 0.0000
R-squared	= 0.9752
Root MSE	= 22.016

patent_app~s	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year_dummy	-4.29714	23.00264	-0.19	0.854	-53.3261	44.73182
treat	283.7527	136.5513	2.08	0.055	-7.299489	574.8048
diff_dummy	41.64758	19.22497	2.17	0.047	.6705323	82.62464
researchers	-.0040769	.0011261	-3.62	0.003	-.006477	-.0016767
berd_tot	.0275007	.0137963	1.99	0.065	-.0019054	.0569068
year	9.107455	8.212724	1.11	0.285	-8.397552	26.61246
_cons	-17844.9	16379.96	-1.09	0.293	-52757.97	17068.17

```
Ramsey RESET test using powers of the fitted values of patent_applications
       Ho:  model has no omitted variables
                  F(3, 12) =      1.31
                  Prob > F =      0.3160

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(21)     =     22.00
         Prob > chi2  =    0.3995
```

(n = 22)	D-H	P-value	asy.	P-value
Residuals	3.7126	0.1562	1.9728	0.3729

Annex 7: Final model estimated for the placebo Denmark counterfactual scenario in the long time frame and relative tests (stata output)

```
Linear regression                               Number of obs     =         38
                                                F(5, 32)          =      77.14
                                                Prob > F          =     0.0000
                                                R-squared         =     0.8946
                                                Root MSE          =     62.578
```

patent_app~s	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year_dummy	-1.730378	24.70453	-0.07	0.945	-52.05185	48.5911
treat	466.3186	153.0176	3.05	0.005	154.6319	778.0053
diff_dummy	149.7361	75.54651	1.98	0.056	-4.147097	303.6193
researchers	-.0088899	.0038379	-2.32	0.027	-.0167076	-.0010723
berd_tot	.0685637	.0290501	2.36	0.025	.0093907	.1277368
_cons	143.8618	21.52664	6.68	0.000	100.0135	187.7101

```
Ramsey RESET test using powers of the fitted values of patent_applications
       Ho:  model has no omitted variables
                  F(3, 29) =      0.95
                  Prob > F =      0.4284

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(14)     =     26.41
         Prob > chi2  =    0.0229
```

(n = 38)	D-H	P-value	asy.	P-value
Residuals	0.2934	0.8636	0.5613	0.7553

Annex 8: Final model estimated for the placebo Denmark counterfactual scenario in the short time frame (stata output)

Linear regression

Number of obs	=	22
F(5, 16)	=	159.42
Prob > F	=	0.0000
R-squared	=	0.9731
Root MSE	=	34.531

patent_app~s	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year_dummy	-.0849725	25.62185	-0.00	0.997	-54.40088	54.23093
treat	300.5944	103.5356	2.90	0.010	81.10877	520.0799
diff_dummy	34.17738	32.69929	1.05	0.311	-35.14201	103.4968
researchers	-.0014447	.0021613	-0.67	0.513	-.0060264	.0031371
berd_tot	.0148493	.0220092	0.67	0.510	-.0318082	.0615068
_cons	153.0009	25.02545	6.11	0.000	99.9493	206.0525