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TITOLO TESI

A Law and Economics Analysis of Trade Secrets: Optimal Scope of Law, Misappropriation and Alternative Damages Regimes

Presentata da: Arun Kumar KAUSHIK_____

Coordinatore Dottorato

PROF. LUIGI ALBERTO FRANZONI

_____

Relatore

PROF.MR.DR. LOUIS T. VISSCHER
PROF. LUIGI ALBERTO FRANZONI

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[†]This paper is co-authored with Prof. Luigi Alberto Franzoni.

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DEDICATION

To my grandfather Mr. Durga Prasad and my life mentor Mr. Harish Sharma

Chapter 1

INTRODUCTION

In this age of continuous technological advancements, where intangible assets have become much more important as compared to the tangible assets of firms (Brennan & Connell (2000)), management of intangible assets has become very important. Trade secrets are one of the most important ways to protect the intangible assets of firms[1]. This thesis explores trade secrets, often considered to be an aspect of intellectual property and a topic which generally falls under this subject area[2]. Trade Secrets law, which protects companies against the misappropriation of the secrets by rivals and employees, plays a fundamental role in modern economic systems. It remains, however, an under explored topic.

In the economic literature, most of the work on intellectual property focuses on patents. However, empirical studies have shown the importance of trade secrecy over patents as a method of protection of the intellectual property resources of firms[3]. Some recent studies on intellectual property protection have shown that patents are the least favoured method of protection, which points towards the importance of non

[1] Almeling (2012) presents several reasons why trade secrets are increasingly important.

[2] In the United States, trade secrets are considered to be Intellectual Property rights. However, some countries in Europe do not consider them as Intellectual Property rights. For more information, refer to the Baker & McKenzie report, 2013.

[3] It may be noted that trade secrets are explicitly considered to be intellectual property in many legislations across the world. We will discuss it further in the following pages.

registered intellectual assets such as trade secrets (Hall et al, 2013). There have been some other studies which analyse the preferences of firms between secrets and patents and nearly all of them find that firms prefer trade secrets over patents for both product innovations and process innovations[4].

Trade Secrets law in its modern form was created in the nineteenth century. During the industrial revolution, the need for trade secrets law became clear after decisions of English and American courts on damages for misappropriation of trade secrets in 1817 and 1837 respectively[5]. However, trade secrets protection is claimed to be found as far back as the Roman period. Schiller (1930) argues that the Roman courts created "*actio servi corrupti*", which literally refers to an action for corrupting a slave. He contends that the "*actio servi corrupti*" was a protection mechanism for the slave owners against third parties who would "corrupt" slaves and make them reveal the secret information belonging to their owners. With the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement, trade secret protection has become an explicit cornerstone of the international intellectual property policy.

Trade Secrets are generally understood as secret information which gives its owners an edge over its competitors. At the international level, the definition of Trade Secrets is provided by the TRIPS agreement of the members of the World Trade Organisation (WTO). Section 7, Article 39 of TRIPS defines Trade Secrets as:-

"Natural and legal persons shall have the possibility of preventing information lawfully within their control from being disclosed to, or acquired by, or used by others without their consent in a manner contrary to honest commercial practices so long as such information:

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[4]We will discuss these studies in detail in Chapter 4 of this thesis.

[5]Cases: In 1817, England - Newbery v. James, 35 Eng. Rep. 1011 (Ch. 1817); and in 1837, the United States - Vickery v. Welch, 36 Mass. (19 Pick.) 523 (1837).

a) is secret in the sense that it is not, as a body or in the precise configuration and assembly of its components, generally known among or readily accessible to persons within the circles that normally deal with the kind of information in question;

b) has commercial value because it is secret;

c) has been subject to reasonable steps under the circumstances, by the person lawfully in control of the information, to keep it secret."

There are many other definitions available in different parts of the world. For instance, The Uniform Trade Secrets Act (UTSA) states,

"Trade secret" means information, including a formula, pattern, compilation, program, device, method, technique, or process, that:

(i) derives independent economic value, actual or potential, from not being generally known to, and not being readily ascertainable by proper means by, other persons who can obtain economic value from its disclosure or use, and

(ii) is the subject of efforts that are reasonable under the circumstances to maintain its secrecy.

In Japan, a definition is provided by the Unfair Competition Prevention Act. The Unfair Competition Prevention Act, Article 2(6), defines trade secrets as *"technical or business information useful for commercial activities such as manufacturing or marketing methods that is kept secret and that is not publicly known".*

Concurring definitions are provided by some jurisdictions across Europe: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Portugal, Romania, Slovak Republic, Slovenia and Sweden have specific definitions of Trade Secrets in their own legislation. However, all of these definitions are very close to the definition in the TRIPS agreement (Baker & McKenzie report, 2013).

1.1 A Brief Survey of Literature on Trade Secrets

Though lawyers have studied and debated the issues of trade secrecy at great length, the economic analysis on the subject is still emerging. Intellectual Property has been a very important aspect of general innovation policies of lawmakers especially in last few decades [6]. Trade Secrecy is an important issue in the broader policy issues of innovation policies. This is because it poses a potentially informative and useful research area and this is reflected in the ongoing policy debates at the European Union level (Directive proposal of the European Commission (Proposal 2013/0402)). Policy makers are interested in the implications of trade secrets policy and its general welfare implications.

In a famous article, leading researchers in law and economics termed trade secrets as a neglected orphan in economic analysis (Friedman et al, 1991). They contended that despite its importance to the business community at large, trade secrets have not been given enough attention by economics scholars. However, there has been large amount of research on trade secrets since then, and many researchers are working in this area today. Some of the notable issues analysed in the literature are employee mobility, patents-secrecy mix and damages for misappropriation of secrets. Employee mobility is extensively analysed by researchers because of the possible conflict between trade secrets protection and freedom of employees in changing their jobs. Many researchers have looked at patent-secrey mix because of the synergies between them. Some argue that patents and secrets are substitutes while others contend that they are complementary to each other. Damages in case of misappropriation is another issue which is analysed in both the legal and economic literature. We present some of the theoretical literature in this chapter.

[6] See Reichman, J. H. (2009) and Chen, Y., & Puttitanun, T. (2005).

1.1.1 Employee Mobility and the protection of trade secrets

One of the main issues analyzed in this area of research is the mobility of employees and the subsequent effect on trade secret protection strategies. There exists a tension in the relationship between remedies to protect the trade secrets and the ability of ex-employees to use their skills and knowledge in the new employment. Trade secret law may require the employees not to join competing firms or reveal any kind of confidential information which they get from previous employment. Thus it hampers the job prospects of the employees (Kitch, 1996).

Motta and Ronde (2002) analyse the implications of having covenants not to compete clauses on researcher's efforts and the profitability of the firm. They contend that if the researcher's contribution to the innovation process is crucial (observable but not contractual), covenants not to compete reduce both the researcher's efforts and firm's profitability. However, if the firm's R&D investments are the most important aspect, having a non competing agreement is optimal for the firm, as it ensures firms incentives to invest in research.

Zabojnik (2002) looks at how trade secrets can be protected by means of compensation in case of employee mobility. He contends that in most states in the US, the law restrains the employees' movement to protect firms' trade secrets, with the exception of California. Zabojnik analyses how firms protect their secrets using compensation as a tool. His analysis rests on the crucial assumption that each manager has information about the trade secrets at his and his lower levels of hierarchy. He finds that the managers have incentives to overpay their subordinates to protect their secrets. This creates a moral hazard problem which arises because by overpaying the subordinates, they increase the value of those employees to competition and increase their wages. This has clear potential ramifications for the economy as a whole as

some technical roles are remunerated based on the value of secrets held rather than for the work undertaken by the individual.

Fosfuri and Ronde (2004) analyse firms' incentives to locate in an industrial vicinity to benefit from technological spillover with the mobility of employees. They argue that punitive damages are generally beneficial for firms' profits and that they stimulate clustering. In the end, they are not an impediment to technology spillovers. Their analysis suggests that weak trade secret protection might not be a prerequisite for clustering and labour mobility as some legal scholars (Gilson 1999, Hyde, 2001) have argued.

Bernhardt & Dvoracek (2009) analyse the impact of trade secret protection efforts in terms of wage premia, in a multi-national context. They argue that wage premia can be used to protect trade secrets in addition to non competing contracts. The authors focus on the strategic behaviour of multinational firms with superior technology operating in a developing country. The domestic firms may want to hire employees of the multinational firms in an effort to access the superior technology and secrets of the multinationals. However, wage premia can be used to restrain the employees from joining the domestic firms. In this way, multinational firms can retain their technological superiority and protect their trade secrets.

1.1.2 Patents and Secrecy

There is a branch of literature which looks at the interactions and mixture of patents and secrecy to protect the innovation.

Anton and Yao (2004) argue that in equilibrium large innovations are protected by secrecy, small inventions are not imitated whereas the medium sized inventions are licensed by the inventor when the property rights are weak. Their arguments are based

on three basic assumptions; that innovation creates asymmetric information; that it has limited legal protection; and, that disclosure creates incentives for imitation. The innovator's choice of intellectual property rights and disclosure plays a signalling role for imitation. The imitators base their decision to imitate on the innovator's choice of disclosure. They argue that small inventions are always patented, and, there will be no imitation because the risk of paying damages outweighs the marginal benefit from imitation. For medium innovations, the marginal benefits may exceed the risk of paying damages due to infringement and thus the imitator may imitate. However, the innovator would find it better to license the medium innovation. With a large innovation, the innovator protects his innovation by secrecy to reduce the chances of imitation because the profits by keeping the invention to himself ensures larger profits to him.

Denicolo and Franzoni (2004) present a model of optimal patent design when innovators can protect their inventions with secrecy as well. The authors investigate whether the prevalence of trade secret protection by innovating firms is socially desirable. They build a two stage model, an innovation stage where the innovator chooses the research effort level and decides on the protection mechanism and a duplication stage where the duplicator decides on the effort to duplicate. The innovator has to balance the limited benefit of patent protection against the duplication risk associated with keeping innovation secret. These authors show that patents are superior to trade secrets in a broad set of circumstances, because they provide better incentives to innovate (no reward for the loser of the innovation race). Furthermore, patents prevent wasteful duplication costs. If the competition intensity in the product market is not too strong, patents lead to smaller deadweight losses as well.

Denicolo and Franzoni (2012) concentrate on the cases where research spillovers

arise in the innovation race, and analyse conditions for the desirability of a strong form of protection which grants exclusive rights to the innovator as opposed to weak forms of protection, which allow some sort of imitation and competition. It is argued that the comparison between the two alternatives boils down to a specific "ratio test," which suggests that strong, exclusive intellectual property rights are better when the competition from potential imitators is weak, the innovation induces large R&D investments, and the research spillovers are sufficiently small.

Jorda (2008) claims that trade secrets are not solely applicable as protection devices to early stage inventions, sub-patentable innovation or manufacturing processes as is commonly believed. It is argued by the authour that contrary to the conventional wisdom, inventors may rely on trade secret protection in conjunction with, and complementary to, patents to protect the tremendous volume of collateral or associated know how that might exist for any patentable invention. "Patents are but tips of icebergs in an ocean of Trade Secrets", Jorda argues.

Ottoz and Cugno (2008) also argue that different protection mechanisms may be employed at the same time when an innovation is comprised of separately protectable components. If patents and trade secrets can be mixed in protecting single innovations, then surprisingly a strengthening in patent breadth may induce a lower level of patenting, as innovators are prone to rely more on secrecy in that case. Ottoz and Cugno (2011) analyse optimal trade secret policy based on the optimization of economic welfare. They build a model with an incumbent firm having a product whose technology consists of two components, one protected by patent and the other by secrecy. The principal argument is that the duplication costs can be limited with strong trade secret law. Thus, they suggest strong trade secret law.

The literature is growing rapidly and it is not the objective of this thesis to present

all dimensions of the general literature on trade secrets. We focus on specific issues revolving around trade secrets law. Hence the literature we present is related to the issues we analyse in this thesis. There is another important strand of literature on the remedies in case of misappropriation of trade secrets. We look at some of the studies focusing on damages for misappropriation of trade secrets in Chapter 3 of this thesis. The empirical literature on trade secrets is presented in Chapter 4 of this thesis.

1.2 Policy Relevance

Trade secrets law is currently going through a period of significant reforms and modifications in various parts of world. In particular, the European Union and the United States are strengthening their legal protection for trade secrets. In the European Union, a new legal framework of the union to protect trade secrets against misappropriation is set to be operational soon[7]. In the United States, stronger protection of trade secrets, especially against foreign companies or foreign governments is being pushed for[8]. We present these policy debates and the specific legal changes below.

1.2.1 In the European Union

On 26 May 2014, the council of the European Union agreed on a general approach[9] for establishing a new legal framework for the protection of trade secrets (9870/14). The new framework is expected to make it easier for national courts to deal with the misappropriation of trade secrets/confidential business information. It also aims at

[7]For the full text of the proposed directive see the following link: (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0813:FIN:EN:PDF).

[8]Please refer to Administrative Strategy on Mitigating the Theft of US Trade Secrets (2013) for more details.

[9]It should be noted that the EU parliament has not delivered its opinion yet.

making provisions for removing the trade secret infringing products from the market, and making it easier for victims to receive compensation for illegal actions.

The president of the Competitiveness Council, Notis Mitarachi, made the following comment:-

"Today, we have decided on a single, clear and coherent legal regime protecting against misappropriation of trade secrets in EU Member States. This decision will promote innovative companies, ensure fair and honest competition and create a secure environment conducting to innovation, the exchange of valuable know-how and cross-border commercial activities within the internal market. This will empower companies to continue investing with more confidence in research and innovation in Europe."

Under this agreement[10], the new framework is characterised by the following features:

i) a minimum harmonisation of the different civil law regimes, whilst allowing member states to apply stricter rules;

ii) the establishment of common principles, definitions and safeguards, in line with international agreements, as well as the measures, procedures and remedies that should be made available for the purpose of civil law redress;

iii) a limitation period of six years for claims or bringing actions before courts;

iv) the preservation of confidentiality in the course of legal proceedings, while ensuring that the rights of the parties involved in a trade secret ligation case are not undermined;

v) the establishment of a favourable regime to employees in what concerns their liability for damages in case of violation of a trade secret if acting without intent.

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[10]The press release of the council of the European Union can be found at: http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/142780.pdf

The new provisions would come into effect, at the latest, one year after the final adoption of the directive.

1.2.2 In the United States

Similarly, debates are going on for stronger legal protection against trade secret misappropriation in the US. In 2013, the United States released the "Administration Strategy on Mitigating the Theft of US Trade Secrets[11]" which suggests for increased protection for trade secrets both domestically and internationally.

The strategy suggests a whole governmental approach to stop the theft of trade secrets by foreign competitors or foreign governments by either means- cyber or otherwise. The specific features of the strategy are as follows:

i) First, the government wants to increase the diplomatic engagement. The US government will convey its concerns to countries where there are high incidents of trade secret theft with coordinated and sustained messages from the most senior levels of the administration. The government will urge foreign law enforcement to do more, and, will use its trade policy tools to press other governments for better protection and enforcement.

ii) Second, the government will support industry-led efforts to develop best practices to protect trade secrets and encourage companies to share with each other best practices that can mitigate the risk of trade secret theft. Promotion of voluntary best practices by private industry will be encouraged.

iii) Third, Department of Justice will continue to make the investigation and prosecution of trade secret theft by foreign competitors and foreign governments a

[11] This strategy report can be found at:
http://www.whitehouse.gov/sites/default/files/omb/IPEC/admin_strategy_on_mitigating_the_theft_of_u.s._trade_secrets.pdf

top priority. Enhancement of domestic law enforcement is another area to focus.

iv) Fourth, the government wants to improve the domestic legislation dealing with trade secrets. The government will also conduct a review of their laws to determine if further changes are needed to enhance enforcement.

v) Lastly, the government will increase public awareness of the threats and risks to the U.S. economy posed by trade secret theft.

The organisation for Economic Co-operation and Development (OECD) published a working paper by Lippoldt and Schultz (2014), which looks at the relationship of the stringency of the protection of trade secrets to various economic indicators, using data from a sample of 37 countries for the period 1985-2010. They find a positive association between the stringency of trade secrets protection and key indicators of innovation and international economic flows.

They argue that through these relationships trade secrets protection may have implications for developments in innovation, international technology transfer and access to technology intensive inputs and related products. However, it should be noted that this study presents associations of variables and does not provide any causality.

In this thesis, we look at questions revolving around the optimal scope of trade secret law, desirability of alternative damage regimes in terms of incentives to misappropriate, incentives to innovate, and ex-post welfare. Further we look at relationship between trade secrets sharing and misappropriation using a novel survey data. The next section provides a brief sketch of the research problems and the results.

1.3 Research questions and findings in a nutshell

This thesis is primarily based on three core chapters, focused on the fundamental issues of trade secrets law. It is largely a policy oriented research in a bid to improve legal institutions. The goal is to come up with policy recommendations to improve legal structure governing trade secrets. The focal points of the first part of this research are the following. What is the optimal scope of trade secrets law? How does it depend on the market characteristics such as degree of product differentiation between competing products. What factors need to be considered to balance the conflicting objectives of promoting innovation and knowledge diffusion? The second strand of this research focuses on the desirability of lost profits or unjust enrichment damage regimes in case of misappropriation of a trade secret. A comparison between these regimes is made and simple policy implications are extracted from the analysis. The last part of this research is an empirical analysis of a possible relationship between trade secrets sharing and misappropriation instances faced by firms. The research questions studied in these chapters provide several policy implications which may be used by the law makers to improve the legal structure governing trade secrets. The research questions studied in different chapters are summarised below.

1.3.1 Chapter 2

The second chapter of this thesis looks at the question of the optimal scope of trade secrets law. A simple model is developed where one innovative firm invests resources in creating and protecting its secret knowledge. A rival firm invests resources to ferret this knowledge out. Once the knowledge is created by the innovative firm, it enters a "secrecy contest" with the rival firm. Trade secrets law reduces the probability of disclosure of the trade secret. It is shown that with stronger protection of trade

secrets, the secret owner reduces her efforts in keeping the secret and the imitator reduces her efforts in extracting the secret.

Stronger trade secrets law also increases the incentives to innovate by increasing the payoff to the innovative firms. However, it also retards competition by inhibiting diffusion of innovative knowledge in the society. Thus, there exists a tension between incentivising the innovator with stronger protection and promoting greater welfare by allowing the dissemination of innovative knowledge. A proper balance between these two objectives depends on the intensity of market competition in the product market, the cost of self-protection by the owner of the secret and secret extraction costs. We show that maximal protection is warranted when product market competition is weak, cost of self-protection is low and cost of secret extraction is high.

In the case of horizontally differentiated goods, however, the optimal scope of trade secrets law is thinner. Product differentiation dilutes the incentives of the parties to invest in the secrecy contest. It enhances the value of entry for the consumers, but also allows firms to charge more. This result has interesting ramifications in the context of unfair competition law. For instance, in Germany, courts consider the degree of similarity between the products before delivering their verdicts. The chances of a suit under unfair competition succeeding in court is higher if the products are similar to each other (see de Vrey 2006).

1.3.2 Chapter 3

The third chapter of this thesis focuses on civil remedies available to the owner of the secret in case of misappropriation. In particular, we look at alternative damage regimes and their implications on market competition and welfare.

A model of simple oligopoly competition with asymmetric information is devel-

oped. The asymmetry arises in the following sense: the owner of the secret does not know whether the duplicator has introduced a similar product by misappropriating the secret formula, or developed the product by independent research. The possibility of receiving damages affects the payoff to the owner of the secret, and, hence the market outcome. Similarly, the possibility of paying damages affects the payoff of the duplicator who misappropriated the secret. Furthermore, the specific doctrine regime affects the market outcomes in their own manner. We focus on the lost profit and the unjust enrichment doctrines of damages and analyse their impacts on the behaviour of the owner of the secret and market outcome. A comparison between these two regimes is made in terms of the output and payoffs of the players.

The owner of the secret is better off under the lost profit regime whereas the duplicator who develops his product with independent research is better off under the unjust enrichment regime. The duplicator who misappropriates the secret can be better off or worse off under either regime, depending on the parameters of the model.

It is found that the unjust enrichment regime results in higher welfare as compared to that under the lost profit regime. Further, the incentives to misappropriate are expected to be higher or lower, depending on the degree of accuracy of courts and on the proportion of violators (duplicators who misappropriate the secret). We provide clear conditions under which the lost profits regime provides greater incentives to misappropriate as compared to that under the unjust enrichment regime.

1.3.3 Chapter 4

This chapter details an empirical study which focuses on the problem of misappropriation and its relationship with trade secret sharing behaviour of firms with third parties. There is little empirical work on trade secrets as compared to other forms

of intellectual property. In the existing literature, trade secrets have mostly been studied with reference to patents. In this chapter, however, we look at novel survey data, focused mainly on trade secrets. The survey looks at many important aspects of trade secrets protection. This helps us to look at the relationship of trade secrets sharing and their misappropriation by various parties.

This chapter attempts an empirical investigation to analyse the importance of trade secrets to companies using a sample of firms in European countries, "Survey on trade secrets and confidential business information in the internal market", prepared by Baker & McKenzie (2013) for the European Commission. This survey was developed to understand trade secret information sharing and misappropriation incidences. Novel survey data of 486 European firms is used to analyse several research questions. A relationship between the importance of trade secrets for the firms, information sharing and misappropriation behaviour is established.

The results of this empirical work can be summarised as follows. We find that firms that share trade secrets information with third parties are more likely to face acts/attempts of misappropriation of their trade secrets. We also find that firms are more likely to find secrecy important for their inventive knowledge, technical information and business information if they make high usage of patents, which points towards possible synergy between patents and secrecy. This is in line with recent research on the complementary nature of patents and trade secrecy.

Finally, we conclude the main findings of this thesis in Chapter 5.

Chapter 2

THE OPTIMAL SCOPE OF TRADE SECRETS LAW[1]

This chapter investigates the optimal scope of trade secrets law by means of a simple model. In the model, one innovative firm invests resources first to produce knowledge, and then to protect it from unwanted disclosure. A rival firm invests to ferret this knowledge out. Trade secrets law affects this "secrecy contest" by reducing the probability of disclosure given the efforts of the parties. We show how optimal trade secrets policy depends on structural market features and cost parameters.

2.1 Introduction

In modern economies, the competitive advantage that firms enjoy on the market depends more and more on their specific know-how and knowledge, rather than manufacturing costs differentials. The protection of "intangible assets" from unwanted disclosure is thus of paramount importance. For this purpose, firms can rely on different legal tools, including patents (for non-obvious inventions) and copyright (for novel pieces of creative work). Yet, most companies tend to rely on the oldest, and probably cheapest, form of protection: secrecy.[2]

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[1] THIS PAPER IS CO-AUTHORED WITH PROF. LUIGI ALBERTO FRANZONI.

[2] Recent empirical investigations by Hall et al. (2013) show that only 4% of UK innovating companies patent. In the US, about 5.5% of all manufacturing firms engage in patenting activity (Balasubramanian and Sivadasan 2011).

The effort of companies to protect their competitive knowledge by means of secrecy is not discouraged by the law. To the contrary, the law supports the secret conservation of knowledge, by sanctioning conducts aimed at the violation of secrets, like unauthorized disclosure and espionage. In this respect, however, the law is called upon to strike a difficult balance between the right of the knowledge holder to preserve secrecy, and the need of society at large to get access to the information secretly held. The diffusion of innovative knowledge favours imitation and fosters competition on the market.[3] Excessive secrecy protection, by retarding the diffusion of information in the economy, might not serve the interests of the consumers well.

In this chapter, we investigate the optimal scope of trade secrets law and highlight the basic trade-offs that it should address. In particular, we develop a simple model in which an innovative firm exerts effort to protect its competitive knowledge, while another firms invests resources to ferret this knowledge out. Before illustrating the model, it is important to clarify the main features of trade secrets law.

As opposed to patent law, which shares the same basic features around the world, trade secrets law varies substantially across countries. In most countries, provisions regulating the protection of confidential know-how are scattered in several bodies of the law, including tort law, contract law, employment law, criminal law, and -sometimes- Intellectual Property law. The country that has made the greatest effort to provide a unified framework of trade secrets protection is probably the US, where the Uniform Trade Secrets Act (UTSA) of 1979, amended 1985, has been adopted by most states.

[3] As aptly remarked by the US Supreme Court in In *Bonito Boats v. Thunder Craft Boats* - 489 U.S. 141 (1989) : "[...] imitation and refinement through imitation are both necessary to invention itself, and the very lifeblood of a competitive economy." In this case, the US Supreme Court invalidated a Florida statute prohibiting plug molding of vessel designs.

Provisions close to those of UTSA have been included in the international Trade-Related Aspects of Intellectual Property Rights (TRIPs) agreement of 1994, which requires World Trade Organization (WTO) member countries to provide legal protection to undisclosed information (art. 39, see below). In spite of the TRIPs, great variations with respect to substantial trade secrets law persist within the EU (Backer-McKenzie 2013).[4] This has prompted an initiative of the European Commission, aimed at imposing uniform legislation across the EU (Proposal 2013/0402).

In order to frame the problem, we will follow the definition of trade secrets ("undisclosed information") provided by the TRIPs, which stipulates that (Art 39.2):

> Natural and legal persons shall have the possibility of preventing information lawfully within their control from being disclosed to, acquired by, or used by others without their consent in a manner contrary to honest commercial practices so long as such information:
>
> (a) is secret in the sense that it is not, as a body or in the precise configuration and assembly of its components, generally known among or readily accessible to persons within the circles that normally deal with the kind of information in question;
>
> (b) has commercial value because it is secret; and
>
> (c) has been subject to reasonable steps under the circumstances, by the person lawfully in control of the information, to keep it secret.

From this definition, we learn that publicly available information and everyday knowledge are not eligible for legal protection; valueless information and information

[4] Undisclosed business information is protected under the common law of confidentiality in England, while it is protected under unfair competition law (*Unlauteren Wettbewerb*) in Germany. In France, the protection of manufaturing secrets is regulated by the Code of Intellectual Property .

not subject to reasonable protection do not qualify as trade secrets.

Remedies for misappropriation usually include injunctive reliefs and damage awards. The latter are commensurate to the actual loss to the owner of the trade secret or the unjust enrichment of the party that has misappropriated the secret. In most countries, courts can also set a reasonable royalty for the use of the secret.

Compared to patents and other types of intellectual property, trade secrecy is characterized by several distinguishing features.

First, it does not require any form of registration. This does not mean, however, that it can be protected at no cost. To the contrary, the "reasonable efforts" required for its protection can be extremely expensive, depending on the type of information concerned. Expenses usually include material costs to avoid disclosure, organizational efforts to avoid the spreading of the information, and the imposition of specific confidentiality restrictions to contractual relationships. Also, litigation in court can be very costly.[5]

Second, the subject matter is extremely broad, as it encompasses any type of undisclosed information able to provide a competitive advantage to its owner. Under the UTSA, for example, a trade secret can explicitly take the form of "a formula, pattern, compilation, program, device, method, technique, or process".[6] In fact, it is hard to see what type of information is *not* eligible for trade secrets protection.

Finally, the law does not provide an "exclusive right" to the holder of the secret.

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[5] For a sample of civil suits filed in Middlesex County, Lerner (1994) finds that, on average, 43% of the intellectual property cases involve trade secrecy. The share of trade secret cases is significantly higher for smaller firms.

[6] The Economic Espionage Act goes as far as to explicitly include "all forms and types of financial, business, scientific, technical, economic, or engineering information, including patterns, plans, compilations, program devices, formulas, designs, prototypes, methods, techniques, processes, procedures, programs, or codes, whether tangible or intangible, and whether or how stored, compiled, or memorialized physically, electronically, graphically, photographically, or in writing" (§1839).

Rather, the law draws the line between the sets of the lawful and unlawful ways in which information can be obtained and used. In order for civil remedies to be applicable, the secret should have been acquired by "a manner contrary to honest commercial practices," which means, under the TRIPs: "at least practices such as breach of contract, breach of confidence and inducement to breach, and includes the acquisition of undisclosed information by third parties who knew, or were grossly negligent in failing to know, that such practices were involved in the acquisition." (art. 39, footnote 10). Under the UTSA, improper means of acquisition of a secret include: "theft, bribery, misrepresentation, breach or inducement of a breach of a duty to maintain secrecy, or espionage through electronic or other means." Conversely, independent creation, discovery through reverse engineering, and acquisition from public sources represent traditional forms of legitimate appropriation of the secret.[7] By drawing the line between the lawful and unlawful ways in which information can be acquired, the law defines the *scope* of trade secrets law.

The following examples illustrate the point. Let us consider the case of an employee who leaves her company to work for a competitor. Should the employee be allowed to take with her the knowledge acquired in her first job? Former employees are usually not allowed to disclose this knowledge (e.g. customers data) if it qualifies as a trade secret, while they are allowed to do it, if it is part of their "general skill and knowledge." In drawing the line between "trade secrets" and "general skill and knowledge," courts and legislatures will have to balance the opposing goals of encour-

[7] "A trade secret law, however, does not offer protection against discovery by fair and honest means, such as by independent invention, accidental disclosure, or by so-called reverse engineering, that is by starting with the known product and working backward to divine the process which aided in its development or manufacture," Kewanee Oil v. Bicron, 416 U.S. 470 (1974). See also Chicago Lock Co. v. Fanberg (676 F.2d 400, 9th Cir. 1982) and Bonito Boats, Inc. v. Thunder Craft Boats, Inc. (489 U.S. 141, 1989). This feature is shared by the Directive proposal of the European Commission (Proposal 2013/0402).

aging investment in knowledge and protecting job mobility, which is at the base of free competition. In some jurisdictions, courts do not ponder whether the former employee has actually transferred protected knowledge, but just assume - under the doctrine of "inevitable disclosure" - that this transfer cannot be avoided under the new duties taken up by the employee.[8]

Mobility of *groups* of employees is subject to specific restraints. In some jurisdictions, soliciting the departure of employee teams or departments from rival firms (so called "poaching" or "raiding") is explicitly forbidden. In others, e.g. in California, it is not. California high-tech companies have reacted by agreeing not to solicit each others employees (by means of "cold calls"). This practice, however, has been regarded as anticompetitive by the antitrust authority[9].

Similar considerations arise with respect to the covenants not to compete after the termination of the employment relationship. Law-makers of different jurisdictions assume different stands with respect to the enforcement of these covenants. Californian courts, for instance, tend not to enforce them at all, while other courts take a more cautious stance (usually based on "reasonableness" criteria). Clearly, where non-competition covenants are enforced, the primary producer of the know-how is protected (she has to spend less to retain her employees, she can share information more easily), but diffusion of the knowledge is stymied.[10]

In some other cases, transfer of know-how takes place by means of activities aimed at information gathering. While outright theft of documents is obviously illegal, other forms of information acquisition may or may not be illegal depending on circumstances

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[8] See, for example, *PepsiCo, Inc. v. Redmond*, 54 F. 3d 1262, 1263–64 (7th Circuit 1995).

[9] "Complaint, US v. Adobe Systems Inc., et al.," DOJ, 2010.

[10] California's exceptional labour mobility has been pointed out as a major driving force behind the success of the Silicon Valley's district (see Saxenian 1994). Gilson (1999) underscores the role served by California's lax trade secrets law with respect to labour mobility.

and jurisdictions. In the famous *du Pont vs. Christopher* case,[11] a company hired a pilot to take aerial pictures of a newly build plant, with the purpose of uncovering information about the rival's manufacturing process. The court held that this conduct was an improper means for the acquisition of information of the rival's production technique. While recognizing that "for our industrial competition to remain healthy there must be breathing room for observing a competing industrialist," it concluded that: "Our tolerance of the espionage game must cease when the protections required to prevent another's spying cost so much that the spirit of inventiveness is dampened. [...] To require DuPont to put a roof over the unfinished plant to guard its secret would impose an enormous expense to prevent nothing more than a school boy's trick." In the *Christopher* decision, the main arguments for the prohibition of the conduct relied on the cost of self-protection and the adverse impact of the conduct on inventiveness.[12] These elements are captured in the model below.

In what follows, we develop a simple model able to capture benefits and costs of trade secrets law. We focus on the case in which the secret information provides a competitive advantage to its owner, who has no interest in sharing it. Once the information/know-how is obtained by the "innovator," a rival firm invests resources to ferret it out. At the same time, the innovator invests to protect it. This "secrecy contest" determines the probability by which knowledge spills from one firm to the other, and hence the probability that the market moves from monopoly to duopoly. trade secrets law complements the effort of the innovative firm to keep the information secrets. By making efforts to extract information ineffective, strong trade secrets law

[11] *E.I du Pont deNemours & Co. v. Christopher*, 431 F.2d 1012 (5th Cir. 1970).

[12] While to put a roof over a plant to protect the secrets is an unreasonable request, not to put documents in the trash is regarded as a reasonable measure to keep them secret. In most countries, *dumpster diving* (searching in the trash for informative documents) is a legal activity.

reduces the (wasteful) expenditure of the firms in the secrecy contest. At the same time, however, strong trade secrets law allows the secret holder to fence off competition and retain market power. On this account, strong trade secrets law is not necessarily desirable. In a dynamic perspective, however, one should also consider that the "rent" granted by strong trade secrets law to the secrecy holder provides incentives to the creation of knowledge, to the benefit of final consumers. In this respect, the optimal scope of trade secrets law depends in a substantial way on the sensitivity of the innovative output to changes in the payoff to the innovator.

In Section 2.2, we derive a basic formula to determine the optimal scope of trade secrets law. By strengthening trade secrets law, the policy makers affect the market dynamics by reducing the chances of disclosure and increasing the protection to the trade secret owner, who has to spend less on self protection. This increase in the protection of the secret owner would induce the secret owner to invest higher resources in the discovery of the innovative knowledge *ex-ante.* We derive a simple formula which gives a clear rule to decide whether it is socially desirable to increase the strength of trade secret law. A marginal increase in the strength of trade secrets law is socially desirable if, and only if, the ratio of the surplus deriving from facilitated disclosure (diffusion benefit minus increased secrecy costs) to innovation surplus is less than the elasticity of innovation with respect to trade secrets strength[13]. Note that if the ratio of facilitated disclosure to innovation surplus is lower than the elasticity of innovation, it is better from societal point of view to not hasten the diffusion of knowledge (by having relatively stronger protection) because the innovation effect dominates the disclosure surplus effect. However, if the ratio of facilitated disclosure

[13]Elasticity of innovation with respect to trade secrets strength can be understood as the ratio of percentage increase in innovation to percentage increase in the strength of trade secrets law. In other words, it represents the responsiveness of innovation to changes in the strength of trade secrets law.

to innovation surplus is higher than the elasticity of innovation, it would be desirable to have weaker protection because the innovation effect is dominated by the benefits of hastened disclosure.

This formula allows us to quantify the main effects driving optimal trade secrets law: i) the impact of hindered disclosure on market surplus (negative) and secrecy expenditure (positive), ii) the benefit to society due to enhanced incentives to create innovative knowledge (measured by the "externality" that this knowledge exerts on the consumers and the rival firm), iii) the elasticity of the creation of innovative knowledge with respect to an increase in the payoff to the innovator.

It is remarkable that strong trade secrets law may be optimal even from an ex-post perspective (i.e. even if the elasticity of creation is nil), thanks to its impact on the secrecy expenditure of the parties. This effect resonates with one of the tenets of Landes and Posner (2003), who argue that the main (social) purpose of intellectual property law is to reduce the self-protection expenditure of innovators. We show that strong trade secrets law is optimal ex-post if competition in the product market is not intense, self-protection costs are low and extraction costs are high. With differentiated products, strong trade secrets protection is optimal ex-post if products are weakly differentiated. Product differentiation is relevant because in some jurisdictions (e.g. Germany), an assessment of the degree of similarity of the products generally accompanies unfair competition cases (de Vrey 2006).

We further investigate optimal trade secrets law from an ex-ante perspective. Even in a simple model like ours, welfare effects of trade secrets law can be complex. We show that optimal trade secrets scope has a non monotonic (U-shaped) relationship with the intensity of competition (when goods are homogeneous) and that optimal trade secrets scope decreases with the degree of product differentiation. When prod-

ucts are more differentiated, firms invest less in the secrecy contest, and strong trade secrets law only hinders competition.

The economic literature on trade secret law, and on unfair competition in general, is small. In their pioneering article, Posner, Landes and Friedman (1991) defend trade secrets law on two grounds. On the one hand, trade secrets law complements patent law by protecting those inventions that firms chose not to patent (either because they fail to meet the patentability requirements or because patenting is too expensive).[14] On the other hand, trade secrets law allows firms to reduce the investment in self-protection (a feature captured in our model).

Ronde (2001) investigates the effect of trade secrets law on the organizational structure of firms. In his model, firms can divide production into independent tasks, so as to limit know-how leakage due to labor mobility. He shows, among other things, that the benefits of reducing the information sharing are greatest if the competition in the market is neither very tough nor very weak. Fosfuri and Ronde (2004) analyze the impact of trade secrets law both on the extent of knowledge spill-over (through labor mobility) and the incentives of firms to cluster in the same area (so as to benefit from the spill over, at the cost of more intense product competition). In their model, the strength of trade secrets law is measured by the size of the damages awarded to the first innovator, when a worker moves to a rival firm to develop a follow-up innovation. Without affecting the size of the spill-over, high damages reduce the wage earned by the worker and provide firms with incentives to cluster together. Hence, they increase social welfare. The impact of strong trade secrets law would not

[14] Over the last decade, substantial reseach has been devoted to the patent /secrecy choice, both from and empirical and theoretical perspective (see the review of Hall et al. (2014)). This literature, however, is of tangential interest to us, as we focus on TS as a stand alone branch of the law.

be necessarily positive, however, if trade secrets law reduced labor mobility (which is the case, for example, when injunctive relief is offered to the first firm or when covenants not to compete are enforced by the courts). In our model, we implicitly focus on the second case, by assuming that trade secrets law impacts the probability that knowledge spills from the innovator to a second (non innovating) firm. The next section presents the model.

2.2 The model

In this section we first provide the basic features and the assumptions of the model. The model is based on a secrecy contest between two players, where one party invests to maintain secrecy of some innovative knowledge and the other party invests to get access to that secret information. The investment levels of the players in this secrecy contest combine to determine the probability of leakage. From the optimality conditions of the players, we develop a fundamental rule determining the optimal scope of trade secrets law. Then we look at how the optimal scope depends on the intensity of market competition when the market is characterised by homogenous goods. Further, we analyse how the optimal scope changes when we allow for the possibility of product differentiation in the market. Under product differentiation case, we compare the optimal scope under different kinds of market competition, that is, "Cournot" competition, "Bertrand" competition, and "Collusive" competition. In the subsection "Unfair Competition", we extend the basic model to the specific case of unfair competition in which the innovative knowledge can not be kept secret because the innovative knowledge lies on the face of the product. Similar to the basic model, we look at the optimal policy scope under the "Unfair Competition" case under homogenous goods market and the market characterised by differentiated

goods. The description of the model is as follows.

The model is built on the assumption that one firm, labeled "innovator," can invest in the development of innovative knowledge. This knowledge, if obtained, allows him to monopolize the market. The profits earned by the innovator, however, entice a second firm (the "rival"), which tries to ferret out the secret knowledge from the innovator. The rival invests resources to obtain the information; the innovator invests resources to protect the information. The structure of this "secrecy contest" game is affected by trade secrets law: given the efforts of the firms, the probability of knowledge spill-over is smaller if trade secrets law is stronger. When information spills, the market turns into a duopoly.[15]

The probability that knowledge leaks from the innovator to the rival is:

$$\textit{probability of leakage} = (1-\tau)\,\delta(x,y) = (1-\tau)\,\frac{y}{x+y},$$

where y is the effort exerted by the duplicator to ferret the information out and x the effort exerted by the innovator to protect his information. $\tau \in [0,1]$ captures the strength of trade secrets law: stronger trade secrets law makes leakage less likely, given the efforts of the two parties. If trade secrets law is strongest ($\tau = 1$), the probability of leakage is nil. If trade secrets is weakest ($\tau = 0$), the probability of leakage only depends on the private efforts of the two parties: $\delta(x,y) = \frac{y}{x+y}$. Note that the probabilty of non-leakage is given by $1-\delta(x,y) = 1-\frac{y}{x+y} = \frac{x}{x+y}$. Therefore, the secrecy contest is symmetric for both players, that is, the effects of the actions of both parties equally affect the probability of leakage or the probability of non-leakage of the secret knowledge.

[15] The model can be suitably extended so as to allow for a plurality of duplicators. The qualitative analysis remains unaffected.

The payoff to the innovator, once he has obtained the secret knowledge, is:

$$V_i(x,y) = [1-(1-\tau)\,\delta(x,y)]\,\pi_m + (1-\tau)\,\delta(x,y)\,\pi_d - cx. \tag{2.1}$$

With probability $[1-(1-\tau)\,\delta(x,y)]$ secret information is retained and the innovator earns monopoly profits π_m. With probability $(1-\tau)\,\delta(x,y)$ information leaks to the rival and the innovator earns duopoly profits π_d. The cost of self-protection amounts to cx.

The payoff to the rival is

$$V_r(x,y) = (1-\tau)\,\delta(x,y)\,\pi_d - sy. \tag{2.2}$$

With probability $(1-\tau)\,\delta(x,y)$ the rival ferrets the secret information out and enters the market (where she gets duopoly profits π_d). The effort to capture information costs sy.

In the secrecy contest, the two players will optimally choose x and y so as to maximize their payoffs. In the Nash equilibrium, the following conditions hold:

$$\begin{cases} -(1-\tau)\,\delta'_x(x,y)\,(\pi_m-\pi_d) &= c \\ (1-\tau)\,\delta'_y(x,y)\,\pi_d &= s. \end{cases} \tag{2.3}$$

Note that marginal benefits of effort for the innovator and the rival are not the same. In fact, when the rival enters the market, the loss for the entrant is greater than the gain for the rival: $\pi_m - \pi_d > \pi_d$ (as far as $\pi_m > 2\pi_d$, which is a condition that holds under very mild assumptions[16]). The innovator, therefore, tends to have stronger

[16] This is a standard result in oligopoly theory. See Reinganum (1984) for reference.

incentives to invest in the secrecy contest than the rival.[17] In line with the classic result of Gilbert and Newberry (1982), we can call this observation the *persistence of secrecy.*

Let $\rho = \frac{c}{\pi_m - \pi_d}$ be the relative self-protection cost (cost as a share of gain from protection) , and $\sigma = \frac{s}{\pi_d}$ the relative extraction cost (cost as share of gain from extraction). From eqs. (2.3) , we get:

$$x^* = (1-\tau)\frac{\sigma}{(\sigma+\rho)^2}, \quad y^* = (1-\tau)\frac{\rho}{(\sigma+\rho)^2},$$

and

$$\delta(x^*, y^*) = \frac{\rho}{\sigma+\rho} = \frac{c}{c + s\left(\frac{\pi_m}{\pi_d} - 1\right)} \equiv \delta^*.$$

In equilibrium, the probability of duplication $(1-\tau)\,\delta(x^*, y^*)$ depends on the strength of trade secrets law τ, and on the relative costs in the secrecy contest: $\frac{\partial \delta^*}{\partial c} > 0$, $\frac{\partial \delta^*}{\partial s} < 0$, $\frac{\partial \delta^*}{\partial \pi_m} < 0$, $\frac{\partial \delta^*}{\partial \pi_d} > 0$. Stronger trade secrets law (greater τ) reduces both the self-protection and the extraction efforts.

Note, for future reference, that total secrecy costs amount to

$$cx^* + sy^* = \rho(\pi_m - \pi_d)(1-\tau)\frac{\sigma}{(\sigma+\rho)^2} + \sigma\pi_d(1-\tau)\frac{\rho}{(\sigma+\rho)^2} = (1-\tau)\pi_m\frac{\rho\sigma}{(\sigma+\rho)^2} \tag{2.4}$$

$$= (1-\tau)\pi_m\delta^*(1-\delta^*). \tag{2.5}$$

As in standard rent-seeking games, total secrecy costs are smaller if the two contestants are strongly asymmetric (δ^* close to 1 or δ^* close to 0). Strong trade secrets

[17] Similarly, innovators will have greater incentives to lobby for favorable trade secrets legislation than imitators. Innovators can offer greater salaries to their key employees than imitators.

law reduces the amount of resources wasted in the secrecy game by an amount proportional to $\pi_m \delta^* (1 - \delta^*)$.[18]

Let us move now to the first stage of the game, in which the innovator invests to obtain the new piece of knowledge. From an ex-ante perspective, the expected profit of the innovator is:

$$\Pi_i = eV_i (x^*, y^*) - d(e), \tag{2.6}$$

where $V_i (x^*, y^*)$ is the expected profit that she gets upon discovery (eq. 2.1), e the probability of discovery and $d(e)$ the discovery costs, with $d' > 0$ and $d'' \leq 0$.

Thus, the optimal creation effort e^* solves

$$V_i (x^*, y^*) = d'(e^*). \tag{2.7}$$

By implicit differentiation, we get

$$\frac{\partial e^*}{\partial \tau} = -\frac{\frac{\partial V_i(x^*, y^*)}{\partial \tau}}{-d''(e^*)} = \frac{\delta^* (\pi_m - \pi_d) + \frac{1}{\sigma + \rho}(1 - \delta^*) c}{d''(e^*)} > 0. \tag{2.8}$$

Stronger trade secrets law increases the innovation effort.

Note that at the optimum, we have:

$$\frac{d\Pi_i}{d\tau} = \frac{\partial \Pi_i}{\partial \tau} + \underbrace{\frac{\partial \Pi_i}{\partial e}\frac{\partial e^*}{\partial \tau}}_{0} + \underbrace{\frac{\partial \Pi_i}{\partial x}\frac{\partial x^*}{\partial \tau}}_{0} + \frac{\partial \Pi_i}{\partial y}\frac{\partial y^*}{\partial \tau},$$

where the second and third term are nil because of the optimality of e^* and x^*.

[18] Note that the "rent seeking" specification of the secrecy contest implies that an increase in τ induces the same percentual reduction of x^* and y^*.

Thus,

$$\begin{aligned}\frac{d\Pi_i}{d\tau} &= e^*\delta^*\left(\pi_m - \pi_d\right) - e^*\left(\pi_m - \pi_d\right)\left(1-\tau\right)\delta_y'\frac{\partial y^*}{\partial \tau} \\ &= e^*\left(\pi_m - \pi_d\right)\left[\frac{\rho}{\sigma+\rho} + \left(1-\tau\right)\frac{1}{\sigma\rho}\right].\end{aligned}$$

At the margin, stronger trade secrets law increases the innovator's profits thanks to the reduction in the probability of leakage and the reduction in the extraction effort of the rival.

We can now turn to optimal policy. In this simple set-up, ex-ante social welfare is

$$W = e^*\left\{\left[1-\left(1-\tau\right)\delta^*\right]S_m + \left(1-\tau\right)\delta^* S_d - cx^* - sy^*\right\} - d\left(e^*\right), \tag{2.9}$$

where monopoly total surplus is $S_m = \pi_m + C_m$ (profits + consumer surplus), and duopoly surplus is $S_d = 2\pi_d + C_d$ (profits + consumer surplus).

Trade secrets law affects the self-protection and extraction efforts x^* and y^*, the resulting probability of leakage $\left(1-\tau\right)\delta^*$, and, in turn, the probability that knowledge is created, e^*.

We have

$$\begin{aligned}\frac{\partial W}{\partial \tau} = \frac{\partial e^*}{\partial \tau}&\left\{\left[\left(1-\left(1-\tau\right)\delta^*\right)S_m + \left(1-\tau\right)\delta^* S_d - cx^* - sy^*\right] - d'\left(e^*\right)\right\} \\ &- e^*\delta^*\left(S_d - S_m\right) - e^*\frac{\partial}{\partial \tau}\left(cx^* + sy^*\right).\end{aligned}$$

The first term represents the welfare gain due to additional innovation effort, the second the welfare loss due to protracted monopoly, and the last the welfare gain due

to reduced secrecy expenditure.

In view of (eq. 2.7), (eq. 2.1), and (eq. 2.4), we get

$$\begin{aligned}\frac{\partial W}{\partial \tau} &= \frac{\partial e^*}{\partial \tau}\left\{\left(1-\left(1-\tau\right)\delta^*\right)C_m + \left(1-\tau\right)\delta^*\left(C_d+\pi_d\right) - sy^*\right\} \\ &\quad -e^*\delta^*\left(S_d - S_m\right) + e^*\pi_m\delta^*\left(1-\delta^*\right),\end{aligned} \tag{2.10}$$

that is

$$\begin{aligned}\frac{\partial W}{\partial \tau} &= \frac{\partial e^*}{\partial \tau}\left\{\left(1-\left(1-\tau\right)\delta^*\right)C_m + \left(1-\tau\right)\delta^* C_d + V_r\left(x^*, y^*\right)\right\} \\ &\quad -e^*\delta^*\left(S_d - S_m - \pi_m\delta^*\right).\end{aligned} \tag{2.11}$$

An increase in trade secrets protection stimulates innovation, hinders diffusion, and reduces secrecy costs. Several remarks are in order.[19]

First note that the social benefit of additional innovation effort lies with the "externality" that the innovative knowledge exerts on the rival and the consumers ("innovation surplus"). The gain accruing to the innovator is perfectly balanced, at the margin, by the increase in innovation expenditure. The innovation surplus is higher if larger surplus is netted by consumers on the market (C_m under monopoly, C_d under duopoly), and if the rival gets a larger payoff (expected profits less capturing expenditure). In other words, if the surplus that innovation generates from players (other than the innovator) is higher, the innovation surplus would be higher. For instance, if the consumer surplus is higher, the innovation surplus is higher. Similarly, the profits of the rival comes into existence only when the innovation has taken place. Therefore if the rival gets a larger profit due to innovation (after reducing the expenditure on ferreting out the secret knowledge), the innovation surplus is higher.

[19]It can be seen that $\frac{\partial^2 W}{\partial \tau^2} < 0$. This second order condition of maximisation is a technical condition which ensures that the welfare function can indeed be maximised.

Second, from an ex-post perspective (after the innovative knowledge has been created), an increase in trade secrets protection reduces total market surplus, but also decreases secrecy costs. The net impact is not necessarily negative. We call this component of marginal welfare: Disclosure Surplus. It relates to the welfare effect of measures aimed at "hastening" disclosure once the innovative knowledge has been created. Such measures facilitate the shift from monopoly to duopoly, but also increase the amount of private resources that parties invest in the secrecy game.

From (2.11) , we get our fundamental results.

Proposition 1 *Stronger trade secrets protection is socially desirable if, and only if:*

$$\textit{Fundamental rule:} \quad \underbrace{\frac{\partial e^*}{\partial \tau}\frac{\tau}{e^*}}_{\textit{elasticity of innovation}} > \frac{\overbrace{\tau\delta^*\left[S_d - S_m - \pi_m\left(1-\delta^*\right)\right]}^{\textit{Disclosure surplus}}}{\underbrace{\left\{\left(1-\left(1-\tau\right)\delta^*\right)C_m + \left(1-\tau\right)\delta^* C_d + V_r\left(x^*, y^*\right)\right\}}_{\textit{Innovation surplus}}} \tag{2.12}$$

This formula has a simple explanation. A marginal increase in the strength of trade secrets law is socially desirable if, and only if, the ratio of the surplus deriving from facilitated disclosure (diffusion benefit minus increased secrecy costs) to innovation surplus is less than the elasticity of innovation w.r.t. trade secrets strength. $\tau\delta^*$ is the probability that knowledge is *not* disclosed due to legal trade secrets protection.

In view of our formula, strongest trade secrets protection is definitely optimal under two scenarios. First, if the Disclosure Surplus is negative, then strongest trade secrets protection is optimal irrespective of the level of the elasticity of innovation. Second, if Disclosure Surplus is positive, strongest trade secrets protection is (marginally) superior if the impact of the policy measure on the supply of innovation is sufficiently large. We will comment on these two cases in turn.

Strongest trade secrets protection is desirable ex-post when the gain in market surplus due to hastened disclosure is outweighed by the increase in secrecy costs:

$$\text{Disclosure Surplus} < 0 \quad \Leftrightarrow S_d - S_m - \pi_m (1 - \delta^*) < 0.$$

Disclosure Surplus is more likely to be negative when competition in the duopoly market is weak (so that $S_d - S_m$ is small) and the innovator has the upper end in the secrecy game (δ^* is small).[20]

When the Disclosure Surplus is positive, the usual ex-ante vs. ex-post trade-off emerges. Strong[21] trade secrets law reduces welfare ex-post (by hampering diffusion of the know-how), but fosters innovation. Here, what matters is the size of the elasticity of the probability of innovation (w.r.t. trade secrets strength). If the "production" of innovation is very sensitive to an increase in the reward for the innovator (brought about by an increase in τ), strong trade secrets protection is warranted.[22] In turn, the impact of τ on the reward to the innovator (see eq. 2.8) depends on the intensity of competition upon duplication, and the level of the protection costs.

In spite of the simplicity of the model, trade secrets protection tends to affect market equilibrium and social welfare in a relatively complex way. The following examples illustrate the features of the optimal policy.

Example 1: Homogenous goods.

Let us consider the case in which the goods produced by the two firms are perfect

[20] When δ^* is large, both the variation in market surplus and the variation in secrecy costs are large. However, the impact on market surplus is relatively larger (see eq. 2.10).

[21] Strong trade secrets protection refers to the values of τ close to 1.

[22] Empirical estimates of the elasticity of the supply of innovation are reviewed by Denicolò (2007).

substitutes. The inverse demand function is: $p = 1 - Q$. Marginal production costs are set to zero. Under monopoly, output is $Q_m = \frac{1}{2}$,profits are $\pi_m = \frac{1}{4}$ and consumer surplus is $CS_m = \frac{1}{8}$.

Under duopoly, the output level Q_d depends on the intensity of competition between the firms (upon entry). In order to capture different outcomes, let: $Q_d = k$, with $k \in \left[\frac{1}{2}, 1\right]$. For $k = 1/2$ we get the collusive outcome; for $k = 2/3$ Cournot competition, and for $k = 1$, Bertrand competition. For us, Bertrand competition is only a limit case: if the rival expects zero duopoly profits, she will not spend resources to ferret the secret out.

We have: $\pi_d = \frac{1}{2}k\,(1-k)$ and $CS_d = \frac{1}{2}k^2$.

The Disclosure surplus amounts to:

$$DS = -(3/8) + (1-k)k + k^2/2 - \frac{1 - 2k + 2k^2}{4 + 4\frac{c}{s} - 8k + 8k^2}$$

The Disclosure Surplus increases with the self-protection cost c while it decreases with the extraction cost s (recall that DS is more likely to be positive if δ^* is larger). Figure 2.1 represents the DS with respect to the intensity of competition (k) (given $c > s$).

The Disclosure Surplus is negative when competition in the product market is not intense. Here, the entry of a new firm in the market does not provide substantial gains to the consumers. Under Cournot competition ($k = \frac{2}{3}$), we have $DS < 0$ if, and only if, extraction costs are sufficiently large: $s > \frac{9}{13}c$. For $k \to 1$ (nearly competitive outcome), we get: $DS < 0$ if, and only if, $s > c$.

If DS is positive, the optimal level of τ depends on inequality (2.12). If we assume

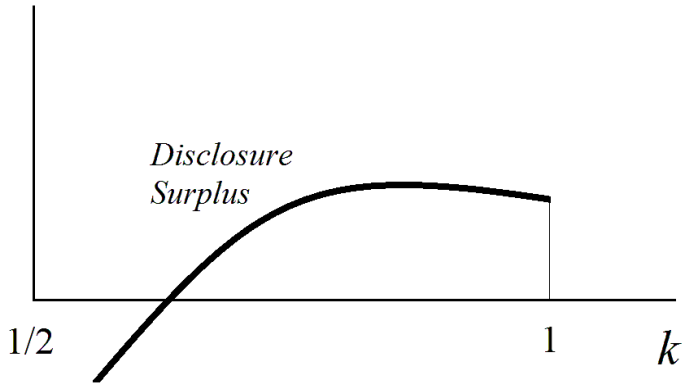

Figure 2.1: Disclosure Surplus as a function of the intensity of competition.

a quadratic innovation function, $d(e) = \frac{1}{2}de^2$, and fix $c/s = 100$, then the optimal scope of trade secrets law depends on k as follows (Figure 2.2):

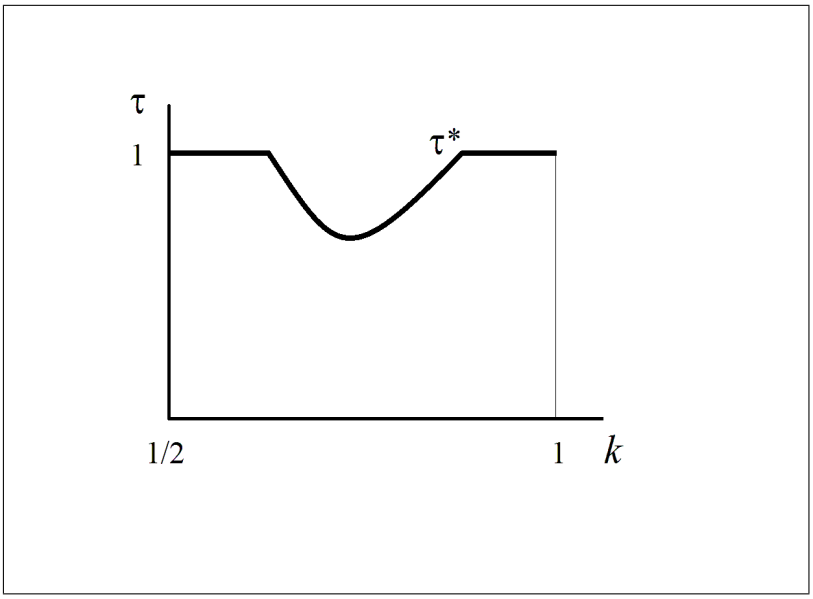

Figure 2.2: Optimal TS scope given intensity of competition.

Perhaps surprisingly, optimal trade secrets scope is maximal both for low levels of products market competition (so that Disclosure Surplus is negative) and high levels of competition (which make the "secrecy contest" more intense). Non-maximal trade secrets protection is optimal for intermediate levels of products market competition.

The next example generalizes the insights obtained to the case of horizontally differentiated goods.

Example 2: Product differentiation

Let us consider the case where the rival is able to supply a product which is different from that supplied by the innovator and neither product dominates the other one.

Let the inverse demand functions faced by the innovator and the rival be, respec-

tively,

$$p_1 = 1 - q_1 - (1 - \beta)\, q_2, \quad \text{and} \quad p_2 = 1 - q_2 - (1 - \beta)\, q_1,$$

where $\beta \in [0, 1]$ is a parameter that captures the degree of product differentiation.[23]

For $\beta = 1$, the two goods are perfectly differentiated. In fact, they are independent of each other. This implies that there is no competition between the innovator and the rival: each producer is a monopolist on her own market. For $\beta = 0$, the goods are perfects substitutes (homogeneous goods). Production costs are set to 0.

The diagram below (Figure 2.3) plots the contour of the Disclosure surplus in the c/s and β space, with respect to different market configurations: Collusion, Quantity Competition (Cournot), and Price Competition (Bertrand). Disclosure surplus is negative underneath the relevant contours (maths in the Appendix).

Figure 2.3 shows the combinations of c/s and β that yield negative Disclosure Surplus (under the relevant contours). Disclosure Surplus is more likely to be negative when goods are weakly differentiated (low β) and the probability of secret disclosure is low (low self-protection cost, high extraction cost). As for the impact of market competition, Disclosure Surplus is more likely to be negative under Collusion than under Cournot. Also, it is more likely to be negative under Cournot than under Bertrand.

[23] See Singh and Vives (1984). The case of complementary goods, that arises for $\beta > 1$, is of no interest here. In fact, when goods are complements, the innovator is always better off if the rival enters the market. In this set-up, stronger TS law facilitates technological transfers and hastens entry.

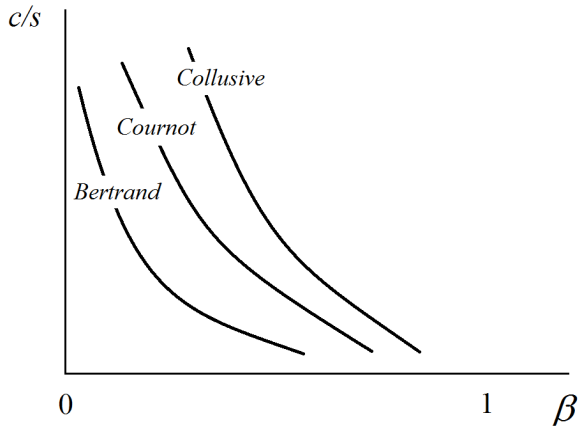

Figure 2.3: Disclosure Surplus as a function of product differentiation

Figure 2.4 plots the optimal level of τ as a function of β, for some levels of the other variables ($c = 1, s = 0.01$).

Trade secrets law's optimal scope declines as goods become more differentiated. In fact, if goods are highly differentiated, the rival does not represent a serious threat to the innovator. Parties spend a limited amount of resources in the secrecy game and the market benefits of fast disclosure outweighed its costs. When goods are weakly differentiated, the secrecy game gains importance (in the welfare analysis). Strong trade secrets law is more likely to be optimal, especially if disclosure does not bring strong benefits to the consumers (collusive outcome).

Note that, in this example, Cournot competition commands a lower trade secrets scope than Bertrand. Under Bertrand, the expenditure of the parties in the secrecy game is the highest. Strong trade secrets protection helps to keep this expenditure

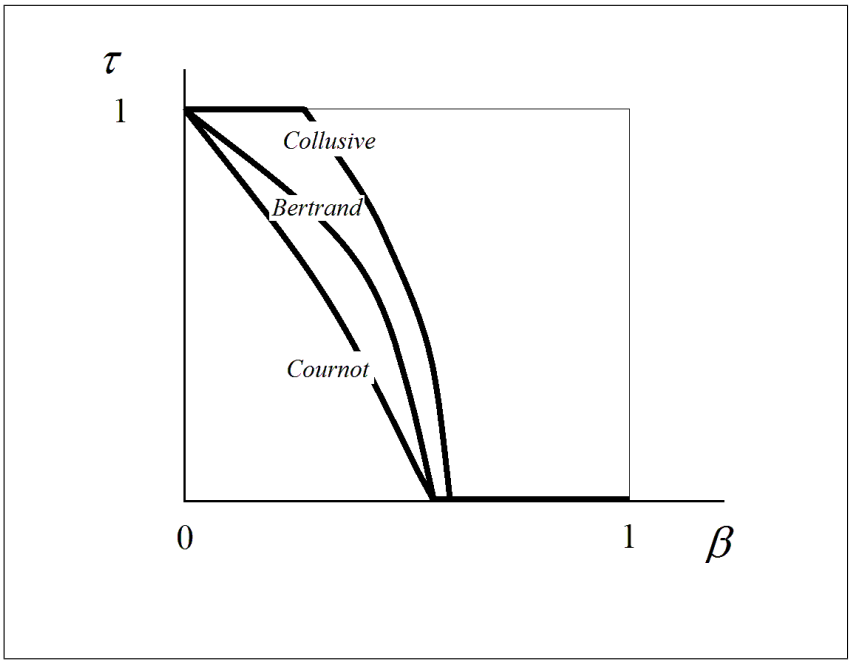

Figure 2.4: Optimal TS scope and degree of product differentiation.

down.[24]

2.2.1 Unfair competition

To further disentangle the factors driving optimal trade secrets policy, let us consider the limit case in which innovative knowledge cannot be concealed: $c \to \infty$. This case arises, for example, when the innovation lies on the face of the product. In the absence of legal provisions[25], the innovation immediately spills to the rival (for simplicity, we stick to the hypothesis that only one firm can imitate the product). "Unfair competi-

[24]Social welfare under Betrand is highest and is the most sensitive to variations in τ.

[25]In this subsection, we focus on non-patentable innovations only. Note that patenting requires stringent conditions such as "novelty" and "non-obviousness" and thus innovations of low values are not generally patented or can not be patented. Thus we restrict our attention to unfair competition law. The subject matter can be thought of as slavish or parasitic imitation.

tion" provisions limiting outright imitation of products exist in many countries (under the heading of *unlauteren Wettbewerb, concurrence déloyale, ongeoorloofde mededinging, competenzia desleal, concorrenza sleale).* Admittedly, British courts tend to apply a rather narrow version of unfair competition, mostly based on the tort of passing off (see Henning-Bodewig 2006, de Vrey 2006).[26] Most civil law countries have statues limiting copycat imitation of (well established) products (*parasitic copying, slavish imitation*). These statutes create "quasi property rights" complementing traditional intellectual property law.[27]

For $c \to \infty$, we get: $x^* \to 0$, $y^* \to 0$, and $\delta^* \to 1$. The only obstacle to imitation is unfair competition law. The product is imitated with probability $1 - \tau$. We get:

$$\lim_{c \to \infty} W = e^* \left\{ \tau S_m + (1 - \tau) S_d \right\} - d\left(e^*\right), \tag{2.13}$$

and (see 2.11)

$$\frac{\partial W}{\partial \tau} = \frac{\partial e^*}{\partial \tau} \left\{ \tau C_m + (1 - \tau) C_d + (1 - \tau) \pi_d \right\} - e^* \left(S_d - S_m\right). \tag{2.14}$$

This expression highlights the standard innovation/diffusion trade-off. Strong protec-

[26] Since 1925, protection agains unfair competition is part of the Paris Convention for the Protection of Industrial Property. Art. 10bis (2) stipulates that "Any act of competition contrary to honest practices in industrial or commercial matters constitutes an act of unfair competition." In particular, the following examples of unfair competition are provided: i) acts that create confusion with the activities of a competitor; ii) false allegations to discredit a competitor, and iii) indications or allegations liable to mislead the public about one's good. Example i) is close the common law tort of passing off.

[27] The British idiosyncrasy for these quasi-property rights has been vividly expressed by Justice Jacob: "There is no tort of copying. There is no tort of taking a man's market or customers. Neither the market nor the customers are the plaintiff's to own. There is no tort of making use of another's goodwill as such. There is no tort of competition" (*Hodgkinson & Corby v. Wards Mobility Services*, 1995, FSR 169)

tion promotes inventiveness, but stymies competition.

Protection should be increased if

$$\underbrace{\frac{\partial e^*}{\partial \tau}\frac{\tau}{e^*}}_{\text{elasticity of innovation}} > \frac{\overbrace{\tau\left(S_d - S_m\right)}^{\text{Disclosure surplus}}}{\underbrace{\left\{\tau C_m + (1-\tau)\left(C_d + \pi_d\right)\right\}}_{\text{Innovation surplus}}} \tag{2.15}$$

Note that Disclosure Surplus is always positive.

With quadratic innovation costs, we get

$$\frac{\partial W}{\partial \tau} = \frac{\pi_m - \pi_d}{d}\left\{\tau C_m + (1-\tau)\, C_d + (1-\tau)\,\pi_d\right\} - \frac{\tau\pi_m + (1-\tau)\pi_d}{d}\left(S_d - S_m\right),$$

and the interior optimal policy is

$$\tau^* = 1 - \frac{\frac{\pi_m}{\pi_m - \pi_d}\left(C_d + 2\pi_d - \pi_m - C_m\right) - C_m}{2\left(C_d + \pi_d - C_m\right) - \left(\pi_m - \pi_d\right)}.$$

In the absence of a secrecy contest, τ affects social welfare through the innovation and diffusion channels. The optimal policy scope is narrower, as shown by the next figure.

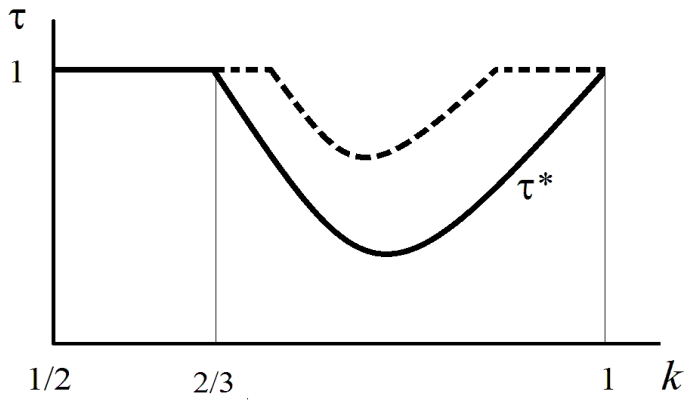

Figure 2.5: Optimal protection against imitation.

Figure 2.5 shows that the optimal scope of unfair competition law (passing off) is substantially narrower in the absence of the secrecy contest. Again, the relationship between k (intensity of competition) and τ^* (optimal protection) is U-shaped.

The optimal protection is maximal for $k \leq 2/3$. With quadratic innovation costs, information sharing and duplication are socially beneficial only if competition is more intense than Cournot competition!

Under product differentiation, a similar result arises. Optimal protection is narrower if the secrecy contest is absent. Below is the case of Cournot competition (Figure 2.6) (Bertrand and Collusion follow similar patterns).

Also in the simple unfair competition scenario, the optimal policy scope decreases with the degree of product differentiation: protection against imitation should be stronger when the product of the rival is a copy-cut duplication of the product of the

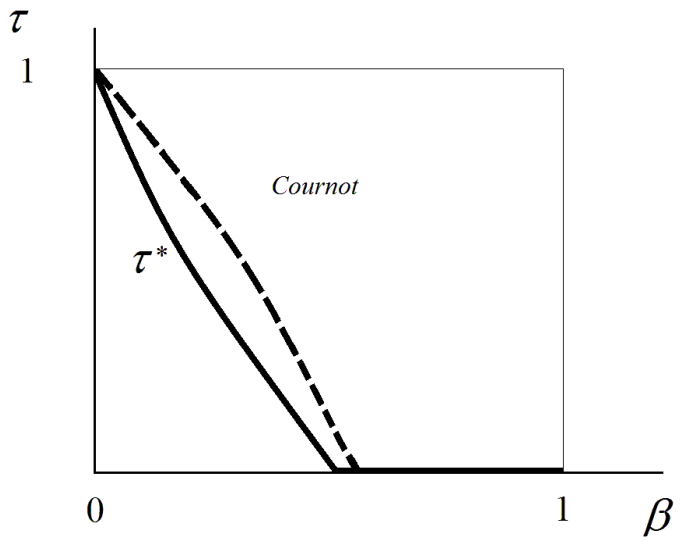

Figure 2.6: Unfair competition vs trade secrets protection

innovator. This is remarkably in line with the legislation of most EU countries.[28]

2.3 Conclusion

Our model sheds light on benefits and costs of trade secrets law. In particular, it is shown that strong trade secrets law reduces the expenditure of the parties in the secrecy game (self-protection vs. extraction). Strong trade secrets law also encourages the creation of knowledge, by increasing the payoff to innovative firms. Strong trade secrets law, however, also hinders the diffusion of innovative knowledge in society and, thus, limits competition. Our model shows that the proper balance between these effects depends on a variety of factors. In particular, we have shown that maximal

[28]Note that our result does not bear on the issue whether protection should be provided by means of IP law or unfair competition law.

trade secrets scope is likely to be optimal when competition in the product market is weak, the cost of self-protection is low, and the cost of secret extraction is high.

The optimal scope of trade secrets law is thinner when the product supplied by the rival is (horizontally) differentiated. Product differentiation dilutes the incentives of the parties to invest in the secrecy contest. It enhances the value of entry for the consumers, but also allows firms to charge more.

The last result has interesting ramifications in the context of unfair competition law. In Germany, for example, cases in which misappropriation of secrets lead to the introduction of goods that imitate those of the secret-owner are decided by considering, inter alia, the degree of similarity between the products. The chances that a suit under unfair competition succeeds in court is higher if the products are close to each other (see de Vrey 2006).

Our model does not address several features of trade secrets law that deserve recognition.

First, we have not considered the case in which the owner of the secret know-how intends to licence it to another firm. Here, trade secrets law may complement contract law in facilitating the transfer, by inhibiting third parties from using misappropriated knowledge.

Second, we have not considered the case in which firms can protect innovative knowledge by means of a plurality of instruments. Stronger trade secrets protection induces companies to rely more on secrecy and less on formal intellectual property rights. With respect to patents, this tends to be a cost. Patents require the disclosure of the invention and have a finite duration. They provide an exclusive right. Secrets can potentially last forever, and are not exclusive. In general, patents tend to provide incentives to innovate at a lower social cost than secrets (Denicolò and Franzoni

2011).[29]

Finally, one should consider that knowledge that is not shared may be lost. This was a concrete possibility in the past, when the secrets (*arcana*) of the craft were jealously held by the master. The case of the Stradivarius violins is paradigmatic. Stradivarius did not share the secrets of his workmanship. With his death, they were lost forever[30]

[29] Trade secrets and patents are compared, under different scenarios, also in Denicolò and Franzoni (2012). See Hall et al. (2014) for a exhaustive review of the literature on the patent/trade secrecy choice.

[30] This example was suggested to us by Hans-Bernd Schaefer. Similarly, the method developed by mathematician Scipione del Ferro (1465-1526) to solve cubic equations is not yet known with certainty. In the 16th century, mathematicians gained their reputation in public competitions where they challenged each other. They would not, generally, reveal their solution methods (de Laat 2000).

Appendix

1) Optimal τ under homogenous goods case:

$$\tau^* = \frac{\begin{array}{c} 16c^3(-1+k)^3k^4(-5+15k-16k^2+4k^3) \\ -4c^2(-1+k)^2k^2(-1-26k+134k^2-296k^3+336k^4-192k^5+32k^6)s \\ -4ck(1-2k+2k^2)^2(-3+20k^2-33k^3+16k^4)s^2+(1-2k+2k^2)^3(7-12k+8k^2)s^3 \end{array}}{\begin{array}{c} 8c(-1+k)k(1-2k+2k^2)(4c^2(-1+k)^2k^2(1-3k+k^2) \\ +ck(7-37k+80k^2-90k^3+48k^4-8k^5)s-(-3+4k)(1-2k+2k^2)^2s^2) \end{array}}$$

2) Optimal τ under differentiated goods, Bertrand competition:

$$\tau^* = \frac{\begin{array}{c} 256c^3\beta^3(-4+9\beta^2+2\beta^3+5\beta^4) \\ +s^3(1+\beta)^2(\beta+\beta^3-2)^3(12-12\beta+3\beta^2-14\beta^3+7\beta^4) \\ -8cs^2\beta(\beta+\beta^3-2)^2(20-4\beta-19\beta^2-16\beta^3-24\beta^4+3\beta^6) \\ +16c^2s\beta^2(-104+44\beta+162\beta^2+29\beta^3+100\beta^4-141\beta^5-30\beta^6-61\beta^7+\beta^9) \end{array}}{\begin{array}{c} (16c\beta(\beta+\beta^3-2)(16c^2\beta^2(3\beta+\beta^3+2)+s^2(\beta+\beta^3-2)^2(2-\beta+3\beta^3)) \\ +2cs\beta(20+12\beta-11\beta^2+4\beta^3-18\beta^4-7\beta^6) \end{array}}$$

3) Optimal τ under differentiated goods, Cournot competition:

$$\tau^* = \frac{\begin{array}{c}-((s^3(-3+(\beta))^2(5-6(\beta)+(\beta)^2)^3(23-34(\beta)+7(\beta)^2)\\ -256c^3(-25+56(\beta)-21(\beta)^2+2(\beta)^3)+\\ 8cs^2(5-6(\beta)+(\beta)^2)^2(177-380(\beta)+200(\beta)^2-40(\beta)^3+3(\beta)^4)+\\ 16c^2s(1885-6042(\beta)+6423(\beta)^2-2748(\beta)^3+523(\beta)^4-42(\beta)^5+(\beta)^6))\end{array}}{\begin{array}{c}(16c(5-6(\beta)+(\beta)^2)(16c^2(-5-2(\beta)+(\beta)^2)\\ +s^2(5-6(\beta)+(\beta)^2)^2(3-10(\beta)+3(\beta)^2)+\\ 2cs(-85+12(\beta)+126(\beta)^2-60(\beta)^3+7(\beta)^4))))\end{array}}$$

4) Optimal τ under differentiated goods, Collusion

$$\tau^* = \frac{\begin{array}{c}(c^3(-4+7(\beta))-cs^2(-1+(\beta))^2(18-29(\beta)+6(\beta)^2)+s^3(-1+(\beta))^3(12-20(\beta)+7(\beta)^2)\\ +c^2s(-16+40(\beta)-25(\beta)^2+(\beta)^3))\end{array}}{(2c(-1+(\beta))(-7cs(-1+(\beta))(\beta)+c^2(1+2(\beta))+2s^2(-1+(\beta))^2(-2+3(\beta))))}$$

Chapter 3

"LOST PROFIT OR UNJUST ENRICHMENT" UNDER MISAPPROPRIATION OF TRADE SECRETS

This chapter analyses civil remedies for misappropriation of a trade secret. In particular we deal with the lost profit (LP) and the unjust enrichment (UE) doctrine of damages and analyse their impacts on the behaviour of the owner of the secret and market outcome. A simple model of asymmetric information is developed, where the owner of the secret does not know whether the duplicator has introduced a similar product by misappropriating the secret formula, or developed the product by independent research. We then compare different remedies available to the owner of the secret, and the welfare impacts thereof. It is found that the UE regime results in a higher welfare as compared to that under the LP regime. Further, the incentives to misappropriate are expected to be higher or lower, depending on the degree of accuracy of courts and on the proportion of violators (duplicators who misappropriate the secret). We provide clear conditions under which the LP regime provides greater incentives to misappropriate as compared to that under the UE regime.

3.1 Introduction

When a firm faces misappropriation of its trade secrets, it may decide to go to courts for legal remedies. This paper deals with two alternative damage regimes in case of trade secret misappropriation, namely the Lost Profit regime and the Unjust Enrichment regime. An attempt is made to understand the market dynamics in case of misappropriation of trade secrets under these two regimes. We also compare the incentives to misappropriate and the ex-post welfare under the two regimes.

Under the Uniform Trade Secrets Act (UTSA) (1985), Section 1 (2) defines "misappropriation" as follows:

(i) acquisition of a trade secret of another by a person who knows or has reason to know that the trade secret was acquired by improper means[1]*; or*

(ii) disclosure or use of a trade secret of another without express or implied consent by a person who

(A) used improper means to acquire knowledge of the trade secret; or

(B) at the time of disclosure or use, knew or had reason to know that his knowledge of the trade secret was:

(I) derived from or through a person who had utilized improper means to acquire it;

(II) acquired under circumstances giving rise to a duty to maintain its secrecy or limit its use; or

(III) derived from or through a person who owed a duty to the person seeking relief to maintain its secrecy or limit its use; or

(C) before a material change of his [or her] position, knew or had reason to know

[1]According to Section 1 (1) of UTSA, *"Improper means" includes theft, bribery, misrepresentation, breach or inducement of a breach of a duty to maintain secrecy, or espionage through electronic or other means.*

that it was a trade secret and that knowledge of it had been acquired by accident or mistake.

The UTSA is adopted by 48 states of the United States of America (only New York and Massachusetts have not adopted it till now). The remedies for trade secrets misappropriation under the UTSA include an injunction, damages, or both.

The focus of this paper is to study the market dynamics under alternative damages regimes[2]. According to the Section 3 of the UTSA, damages can be awarded in the following fashion:

(a) Except to the extent that a material and prejudicial change of position prior to acquiring knowledge or reason to know of misappropriation renders a monetary recovery inequitable, a complainant is entitled to recover damages for misappropriation. Damages can include both the actual loss caused by misappropriation and the unjust enrichment caused by misappropriation that is not taken into account in computing actual loss. In lieu of damages measured by any other methods, the damages caused by misappropriation may be measured by imposition of liability for a reasonable royalty for a misappropriator's unauthorized disclosure or use of a trade secret.

(b) If willful and malicious misappropriation exists, the court may award exemplary damages in the amount not exceeding twice any award made under subsection (a).

Thus the damages are based on three basic principles: i) the economic losses of the secret owner, called Lost Profit; ii) the profits earned by the misappropriator of the secret, called Unjust Enrichment; iii) the amount that the owner of the secret and the potential imitator would have agreed upon if both had been reasonably and

[2]We do not look at injuction because our purpose is to compare the damage regimes.

voluntarily trying to reach an agreement, called Reasonable Royalty[3].

1. The Lost Profit (LP) regime: Under this regime, the losses are measured as a disadvantage to the owner of the secret due to misappropriation. The owner of the trade secret must be able to prove that the losses are a direct consequence of the misappropriation of the secret. In other words, the causation link must be proved in order to get the damages. The burden of proof lies with the owner of the secret.

2. The Unjust Enrichment (UE) regime: The UE damages (also known as disgorgement) are commensurate to the gains that the defendant has obtained from the secret misappropriation. This regime awards the profits of the misappropriator to the secret owner. It is typically used in cases where the loss of profits can not be proved.

3. Reasonable royalty (RR) regime: Royalties are an alternative to the actual damage options. When either lost profits or unjust enrichment can not be proved in court, reasonable royalty is used. Similar to the patent cases, courts usually determine reasonable royalty by analysing a hypothetical negotiation between the parties, if both had been reasonable in their negotiation. This is a quasi-contract[4] that courts create to compensate the trade secret owner in case of misappropriation. This measure typically provides a certain percentage of the defendant's sales revenue (due to use of the secret).

It is important to note that the concept of reasonable royalty in the intellectual property litigations is somewhat problematic and inconsistent. The inconsistency arises because the hypothetical *ex ante* negotiation is supposed to take place before the uncertainty about the rights is resolved, and the question of damages arises only after

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[3]In this study, we do not analyse exemplary damages. Our focus is on basic damage regimes.

[4]A quasi-contract is a legal obligation, not based upon agreement, enforced either specifically or by compelling the obligor to restore the value of that by which he was unjustly enriched (see Corbin, 1912).

the invalidity of those rights (see Schankerman and Scotchmer (2001) and intellectual property (2009)). Hence we analyse the policy implications under different damage regimes focusing on the LP and the UE regimes only.

3.2 Calculation of Damages

It is often difficult to prove lost profits with certainty, and thus courts may use the benefit of the misappropriator to award damages. Even though the conceptual basis of calculating damages is straightforward, the actual calculation in the modern business world is quite complex[5] and thus courts have developed various methods to calculate lost profits[6]. Lost profits are usually grounded upon the plaintiff's lost 'net profits' or 'incremental profits'. This is because if the loss occurred due to lost revenues, one should deduct the incremental costs related with those revenues. Put differently, these are the costs saved by the plaintiff. Another method used by courts is the defendant's sales proceeds multiplied by the profit margin of the plaintiff[7]. At times courts have also used investment value of the trade secret to calculate lost profits. For instance, if a firm loses its secret whose market is not developed fully yet, the court can calculate damages based on the investment value of the secret, that is, on the amount that an investor would have paid to obtain the secret at the time of misappropriation, given the business information at that time[8].

Instead of the lost profits damages, or even in addition to it, courts may award

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[5] Glenn Perdue, The Broad Spectrum of Trade Secrets Damages, Am. Bar Assoc. (Apr. 18, 2012)

[6] Refer to "Trade Secrets Damages: Understanding the Law is a Framework for Success," AIPLA White Paper (October 2013)

[7] This method was used, for example, in David Fox & Sons, Inc. v. King Poultry Co., 23 N.Y.2d 914, 914 (N.Y. 1969)

[8] This method was used, for example, in Precision Plating & Metal Finishing, Inc. v. Martin-Merietta Corp., 435 F.2d 1262, 1263-64 (5th Cir. 1970)

unjust enrichment damages. They can include any gain that the defendant might have received due to the use of the misappropriated trade secret. A practical problem in the calculation of unjust enrichment damages is the duration of the accounting period of the use of the secret. For instance in the *Vulcan Detinning Co. v. Am. Can Co.* case, the court found that the defendant did not know that it was infringing on the secret of the plaintiff, and hence the accounting period for calculating damages started from the date the suit was filed[9]. In another case, the court maintained that the accounting period should start from the date the defendant started marketing the misappropriated product[10].

Therefore, in practice, the calculation of damages can be quite a challenging task. It may potentially involve multiple types of damages. The following case from the US illustrates the issue.

In the *Autopartsource, LLC v. Bruton et al.*[11] case, in 2010, Autopartsource, LLC ("Autopartsource") reassigned its employee Stephen C. Bruton to exert efforts to develop business in China. However Bruton started his own company which directly competed with Autopartsource. He developed his business (BBH Source Group, LLC ("BBH")) secretly with two other partners. In the process of developing his new business, he misappropriated many of Autopartsource's trade secrets. When this came to the notice of Autopartsource in December 2012, Bruton was immediately fired. However, in his last effort to gain an unfair advantage, he entered Autopartsource's California's business premises and deleted much of their databases containing trade secrets. Consequently, a suit was filed against BBH and Bruton. BBH did not file

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[9] Vulcan Detinning Co. v. Am. Can Co., 75 N.J. Eq 542, 544 (N.J.App.Ct. 1909).

[10] Colgate-Palmolive Co. v. Carter Prods., Inc., 230 F.2d 855, 865 (4th Cir. 1956).

[11] Autopartsource, LLC v. Bruton et al., No. 3:13-cv-54, (U.S. Dist. 2013).

an answer to this and therefore the court entered default[12] against BBH on March 6, 2013.

Autopartsource proved violation of the Virginia Uniform Trade Secrets Act (VUTSA). The VUTSA provides for damages which may include both the lost profits and unjust enrichment. Autopartsource demanded compensatory damages of $1,131,801.55. Though BBH did not appear before the court to defend, the court had an independent duty to ensure that the damages demanded were justified. The court found that a part of the damage claim seemed unjustified. The court awarded damages in the following manner.

Autopartsource had submitted evidence of reduced revenues from one of its customers, Intex Auto Parts, by $50,590.85 due to BBH's use of its trade secrets. The court awarded these damages, based on the Lost Profit doctrine. Further, the costs of data recreation was also a direct consequence of misappropriation, and hence a sum of $262,634.87 was awarded to recover the cost of recreate the data deleted by Bruton.

On top of this, given the unjust enrichment damages permitted by VUTSA, Autopartsource sought damages for the time and resources that it spent in building the trade secret (with which BBH had been unjustly enriched). It was argued that Bruton spent approximately 75% of his time in developing the trade secret in question[13]. The court decided to award $616,237.35 as damages under unjust enrichment. Furthermore, Autopartsource sought damages of $202,339.08 to recover from BBH

[12]Default judgment refers to the judgement entered against a party who has failed to defend against a claim that has been brought by another party.

[13]Autopartsource submitted the Declaration of John Amalfe for esimating this. Amalfe said in this declaration that the primary role of Bruton was to conduct the research and development. Bruton developed pricing, marketing and product information that also constituted trade secrets. Thus, the court awarded 75% of Bruton's total compensation from Autopartsource until Bruton formed his company.

all compensation paid to Bruton since he formed the competing company. However, Autopartsource was awarded only $50,584.77, approximately one quarter of what was demanded by it. The claim was brought under unjust enrichment for the salary that Autopartsource paid to Bruton to develop business in China. The argument behind this demand was that BBH was unjustly enriched because Bruton was paid these sums for work performed in China, where he was actually spending his time and effort establishing BBH's business operations. However, there was a logical inconsistency with this argument. The problem with this argument is that it is inconsistent with Autopartsource's theory of recovery for the value of creating the trade secrets-representing 75% of Bruton's compensation throughout his employment ($616,237.35). If Bruton spent 75% of his time working for Autopartsource, as Amalfe also testified, then he could spend at most 25% of his compensable time working for BBH. This is why the total claim from Autopartsource was considered unjustified by the court. Then, the court awarded $75,000 as punitive damages[14], $7,797.96 as attorney's fees, and a permanent injunction on BBH from using a misappropriated trade secret.

For analytical purposes, we look at the LP and the UE regime in isolation in this chapter[15].

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[14]Punitive damages are awarded to punish the defendant, on top of simple compensation.

[15]In other words, we do not study the case where both remedies can be combined. In the existing literature on patent infringement too, these remedies have been studied separately (refer to the literature presented in the next section). Whether remedies are generally combined in practice is an empirical question which goes beyond the scope of this chapter. We simply compare the lost profit and the unjust enrichment regime of damages, following the existing literature on damages for infringement of intellectual property.

3.3 A brief literature overview

The existing literature on infringement of intellectual property has focused on patent infringement, in general, while analysing the impact of different damage rules. The development of trade secrets valuation in case of misappropriation has rested on the shoulders of tools of patent infringement damages valuations and the economic models used for calculation of patents infringement have been adopted to deal with trade secrets cases by courts (Simth (2001), Sickles and Ayyar in Slottje (2006)). The literature on patent infringement is well developed. But trade secrets misappropriation has not received much attention. This chapter attempts to fill this gap in the literature on damages under infringement of intellectual property. In particular, we analyse damage regimes in case of misappropriation of trade secrets. We discuss some of the existing research on patent infringement literature to motivate our analysis. This literature review depicts the basic understanding of the damage regimes for patents which also helps understanding damages under trade secrets misappropriation.

Blair and Cotter (1998) present an economic analysis of damage rules for intellectual property infringement prior to the issuance of injunctions. Their principal argument is that the optimal damages rules should preserve both the incentive structure of intellectual property law and the property-like features of intellectual property rights. They argue that courts should award the highest amount between the LP or the UE damages to the patent owner. On a fairness basis, the patent owner should be able to keep at least his lost profits. At the same time, the infringer should not be able to keep any unjust profits from infringement. They show that the courts in practice follow similar rules as suggested by their analysis. In particular, rules followed in Trade Secrets litigation cases (in the US) appear to adhere to their analysis the most closely among various bodies of intellectual property law.

Schankerman and Scotchmer (2001) investigate how liability rules (use of damages) and property rules (injunction) protect intellectual property[16]. Based on their formulation, they find that infringement might not be deterred under any of the enforcement regimes available, but a credible threat of infringement can actually benefit the patent owner. It is shown that under some circumstances, the patent holder is better off if the infringement takes place. A credible threat of infringement would make the patent holder not agree to license terms that would give him lower profits as compared to what he would get by letting the infringement take place and collecting damages ex-post. The UE regime is more profitable to the patent holder than the LP regime in case of proprietary research tools, when infringement is not deterred. However if infringement is deterred, the two doctrines cannot be compared due to multiplicity of equilibria. Both liability rules can be superior to a property rule depending on how much delay is allowed before infringement is enjoined. However, the results can be reversed for other cases such as end-user products and cost reducing inventions.

Anton and Yao (2007) analyse the impact of damages under patent infringement in an equilibrium oligopoly model of process innovation, in which the choice to infringe is endogenous. They focus on two main questions. First, when does the LP regime deter infringement? Second, if infringement is not deterred, how are innovation incentives impacted by the LP regime?

They find that under the LP regime, infringement always occurs in equilibrium, with the infringer making market choices that affect the profit of the patent holder. In equilibrium the infringement form is either "passive" in which case lost profits of the patent holder are zero, or, "aggressive" in which case they are positive. When

[16]For a general discussion of liability rules and property rules, refer to Calabresi, G., & Melamed, A. D. (1972).

the patentee is protected with the lost profit damage system, incentives to innovate are lower as compared to a system where infringement is deterred. The explanation is that in equilibrium infringement always occurs and the loser in the patent race will always have at least an option of a valuable passive infringement. Since ex-ante innovation incentives are based on the difference between profits of either party being a patentee or being an infringer, the incentives to innovate are reduced under the LP regime.

Choi (2009) investigates how different damage regimes affect competition when intellectual property rights are probabilistic[17]. Choi's analysis rests on an oligopolistic competition model to assess the impact of different damage regimes (the LP and the UE regimes). Choi finds that the LP regime provides more protection to the patent holder than the UE regime if both the patent holder and the infringer have identical marginal costs. Furthermore, after the innovation has taken place, the two damage regimes yield the same social surplus. It is shown that under a linear demand case, social welfare is higher under LP (UE) regime if marginal costs of the patent holder are lower (higher) than those of the infringer. Under the LP regime, enforcement of intellectual property rights is both ex ante and ex post optimal[18] for the patent holder. However, under the UE regime, the patent holder may or may not choose to enforce his intellectual property rights, depending on the probability of detection of the infringement.

Finally, Henry and Turner (2010) study price competition between a spatially differentiated product patentee and an imitator (infringer) anticipating probabilistic future patent damages. Different damage regimes are compared using a model of

[17]Probabilistic intellectual property rights refers to the rights that can be invalidated, if litigated.

[18]It is because patent holder's profits are unambiguously higher if he chooses enforcement.

entry and fixed location Hotelling duopoly. It is found that the reasonable royalty regime yielding symmetric equilibrium prices maximises static welfare and yields the highest innovation incentives when enforcement is almost certain. The LP system may deter infringement and yields the highest innovation incentives when enforcement is less than certain and the products are sufficiently valuable. The UE regime yields both low innovation incentives and low static efficiency. Static welfare is maximal in this set up under the reasonable royalty regime because prices are symmetric and all consumers buy from the closest firm. However, with asymmetric prices (that always occurs under the LP or the UE regime), some consumers do not buy from their closest firm. As a result transportation costs are excessive. It is also argued that entry may be deterred only under the LP regime[19].

The literature just reviewed does not look at the core of trade secrets misappropriation. We provide a simple model to understand the market dynamics for trade secrets misappropriation and the welfare implications of the lost profit and unjust enrichment regimes. A comparison between two regimes is attempted to guide policy makers in deciding the appropriate damage measure.

It is important to note that the study of a patent infringement and trade secret misappropriation are qualitatively different. If a patent holder finds out that somebody else is using her technology, the patent is infringed (patent infringement is a strict liability offence). In a trade secret case, it is often difficult for the plaintiff to know whether the technology used by the defendant was misappropriated. In our model, the owner of the secret is assumed to have a belief (probability) about the

[19]The intuition for this result is as follows. When a product's value increases, the monopolist can increase his price. But the prices in duoplody do not rise. For sufficiently high valued products, expected damages would be high enough to make the expected profit of the imitator negative. Damages in other regimes, on the other hand, are not high enough to deter entry of other firms.

duplicator being a misappropriator. In addition, we assume that the courts can give wrong judgements because it may be difficult to find evidence to prove misappropriation. Thus, courts decide in favour of the owner of the secret with a probability less than 1. We also assume that courts never punish a duplicator who developed the secret formula independently.[20]

The basic findings of this chapter can be summarised as follows. The owner of the secret produces a greater quantity under the LP regime when compared to that under the UE regime. Both kinds of duplicators (one who misappropriates and the other who does not misappropriate the secret) produce a greater quantity under the UE regime when compared to that under the LP regime.

The next section describes the model used in this paper.

3.4 The Model

The model used in this paper is inspired by the patent infringement literature. In particular, the model used in this paper is close to the one used in Choi (2009), but with asymmetric information. The model is described below.

We construct a model of a homogenous product market involving two firms. For illustrative purposes, we use the fragrance market to illustrate the structure of the model. The perfume is produced with a secret formula, which is known to firm 1 only, the owner of the secret. Firm 2 duplicates the product and enters the market with a perfume with exactly the same smell. Firm 1 does not know whether firm 2 has introduced the product in the market by independently developing the secret formula

[20]Note that it may be quite difficult for the owner of the secret to prove misappropriation against the duplicator who has actually misappropriated the secret, it is almost impossible to prove misappropriation against an innocent duplicator.

or by misappropriating the secret of firm 1, using improper means. Firm 2, however, obviously knows whether it discovered the formula independently or misappropriated the secret of firm 1. Thus the model is characterised by asymmetric information on one side. The world is characterised by two kinds of duplicators, misappropriators (violators) and the ones who develop the formula independently, by legal means (non-violators). The proportion of misappropriator duplicators in the population is given by θ and the proportion of independent developers of the secret formula is given by $1-\theta$. The owner of the secret believes that the duplicator has misappropriated the secret with probability θ.

For simplicity, both misappropriation and independent creation of the secret are assumed to be costless[21]. Further, the marginal cost of production is assumed to be zero for this product for both firms. Thus, firm 2 can either steal the secret and bear any potential damages, or avoid the potential damages by discovering the secret formula on its own. The owner of the secret does not know whether the duplicator has stolen the secret or has started producing the good by discovering the secret by proper means. The owner of the secret decides to bring a suit against the duplicator[22]. Once the suit is filed, the court decides whether to award the damages to the owner of the secret or not. However, the court makes the correct judgement only with a probability α. The parameter α represents the difficulty of finding evidence of misappropriation of the secret, given that the secret was actually misappropriated. It should be noted here that the burden of proof is on the owner. It is assumed that the duplicator who

[21]Note that the cost of obtaining the secret is assumed to be costless. However, the violator faces the probability of being punished in the court. Thus, being a violator is costly for the duplicator indirectly. The violator pays damages if he is caught and the owner of the secret proves misappropriation in court.

[22]In our setup, the secret owner always litigates because of the assumption of costless litigation. Our interest lies in post-litigation analysis.

develops the product by legal means is never punished by courts.

Courts award damages if misappropriation is proved. For analytical purposes, we use two measures of damages, namely, the LP and the UE regime, following the literature on damages. Damages can be based on either the LP regime or the UE regime. The objective of this chapter is to study the dynamics of market competition in the case of misappropriation of a trade secret and compare the welfare implications of different damage regimes thereof. We are also interested to compare the incentives to misappropriate or steal the secret under two damage regimes, the LP regime and the UE regime. To keep the model simple and tractable, the market demand is assumed to be linear, and is given by $p = 1 - (q_1 + q_2)$, where q_1 and q_2 represent the quantities produced by firm 1 and firm 2. Let duopoly profits be represented by $\pi_1(q_1, q_2)$ and $\pi_2(q_1, q_2)$ for the owner of the secret and the duplicator when they compete before any ruling by the court. Obviously the market outcome depends on the expected payoffs to the players, which involve damages. However, the expected payoffs to the players depend on the applicable damage regimes in those jurisdictions.

The possibility of award of damages affects the quantities produced by the owner of the secret and the duplicator. For instance, under the LP regime, the duplicator (misappropriator) has to pay damages equal to the profits that the owner of the secret loses due to misappropriation (with some probability). Thus, as compared to the scenario where courts provide no protection of trade secrets, the duplicator internalises the possibility of damages and contracts his output (so that the owner of the secret has a lower loss as a result of misappropriation), and consequently the owner of the secret increases his output. Under the UE regime, the owner of the secret receives the profits of the duplicator with some probability, and thus he behaves in a manner as if the owner has a partial ownership of the duplicator firm. This induces

the owner of the secret to reduce his output (which will give him higher profit of the duplicator in terms of damages) and consequently the duplicator responds by increasing his output, as compared to the scenario with no protection.

We now analyse the market outcomes under the LP regime as well as the UE regime.

3.4.1 The Lost Profit Regime

Here we look at the competition between the players under the LP regime of damages. According to the LP regime, the owner of the secret can recover profits lost due to misappropriation of the secret. It may be noted that firm 1 would have remained a monopolist if the secret was not known to the other firm because the secret formula was known only to firm 1. Hence the loss of profits is equal to the difference between the monopoly profit and the duopoly profit[23]. The expected payoff of the owner of the secret under the LP regime can be represented as:

$\Pi_1^{LP} = \theta(\pi_1(q_1, q_{2v}) + \alpha(\pi_m - \pi_1(q_1, q_{2v}))) + (1-\theta)\pi_1(q_1, q_{2nv})$, or

$$\Pi_1^{LP} = \theta((1-\alpha)\pi_1(q_1, q_{2v}) + \alpha\pi_m) + (1-\theta)\pi_1(q_1, q_{2nv}) \tag{3.1}$$

Firm 1 knows that the proportion of violators is given by θ, so, with probability θ it earns duopoly profit plus the lost profits if the court makes the right decision (with probability α). On the other hand, with probability $(1-\theta)$, the duplicator has discovered the secret formula by legal means and hence the owner of the secret earns only the duopoly profits and gets no damages. The expression q_{2v} represents the

[23]Note that this formulation of the lost profits regime has been extensively used in patent infringement literature (Anton and Yao (2007), Choi (2009)). Choi (2009) argues that this formulation more or less reflects how the rule is implemented in practice, in that the court usually determines damages on the patentee's hypothetical monopoly profit in the absence of infringement.

quantity produced by the violator and similarly q_{2nv} represents the quantity produced by the non-violator.

The payoff of the duplicator includes the payment of the damages if he happens to be a misappropriator and his guilt is proved in the court; otherwise, it is just the duopoly profit. The expected payoffs can be represented as

$$\Pi_{2v}^{LP} = \pi_2(q_1, q_{2v}) - \alpha(\pi_m - \pi_1(q_1, q_{2v})) \tag{3.2}$$

for the violator, and,

$$\Pi_{2nv}^{LP} = \pi_2(q_1, q_{2nv}) \tag{3.3}$$

for the non-violator.

The violator pays damages equal to the lost profits of the owner of the secret with probability α. With probability $1 - \alpha$, the violator does not pay any damages. The non-violator, on the other hand, does not pay any damages, and earns normal duopoly profit[24].

The equilibrium quantities of the players are given by[25]:

$$q_1^{LP} = \frac{1 - \theta\alpha}{3 - 4\theta\alpha + \theta\alpha^2} \tag{3.4}$$

$$q_{2v}^{LP} = \frac{2 - (1 + 3\theta)\alpha + 2\theta\alpha^2}{6 + 2\theta(\alpha - 4)\alpha} \tag{3.5}$$

[24]Since we focus on a homogenous goods market, with zero marginal costs for both players, there is no incentive for the secret owner to voluntarily share the secret with the duplicator.

[25]Please refer to the appendix (1) to see the calculations.

$$q_{2nv}^{LP} = \frac{2 + \theta(\alpha - 3)\alpha}{6 + 2\theta(\alpha - 4)\alpha} \tag{3.6}$$

We observe that the owner of the secret produces a greater quantity as compared to both kinds of duplicators. Further, the violator produces a lower quantity as compared to the non-violator in view of potential damages.

Now we can calculate the expected payoffs of the players as follows:

The owner of the secret

The expected profits of the owner of the secret can be evaluated by plugging in the values of equilibrium quantities(eq. 3.4, 3.5, 3.6) in the payoff function(eq.3.1). We have:

$\Pi_1^{LP} = \theta((1-\alpha)q_1^{LP}(1 - q_1^{LP} - q_{2v}^{LP}) + \frac{\alpha}{4}) + (1-\theta)(q_1^{LP}(1 - q_1^{LP} - q_{2nv}^{LP}))$

or

$$\Pi_1^{LP} = \frac{4 - 3\theta\alpha + 6\theta^2(\alpha-2)\alpha^2 + \theta^3\alpha^3(12 - 8\alpha + \alpha^2)}{4(3 + \theta(\alpha-4)\alpha)^2} \tag{3.7}$$

The expected payoff of the owner of the secret depends on both the probability of facing a violator as well as probability of judgement in his favour given that there was misappropriation of the secret. No monotonic relationship exists between the expected profit of the owner of the secret and the probability of facing a violator, or, the probability of judgement in favour of the owner of the secret.

The Duplicator

For the violator, we have(eq.3.2):

$\Pi_{2v}^{LP} = \pi_2(q_1, q_{2v}) - \alpha(\pi_m - \pi_1(q_1, q_{2v}))$

$= q_{2v}^{LP}(1 - q_1^{LP} - q_{2v}^{LP}) - \alpha(\frac{1}{4} - q_1^{LP}(1 - q_1^{LP} - q_{2v}^{LP}))$

or

$$\Pi_{2v}^{LP} = \frac{(1-\alpha)(4-(1+12\theta)\alpha+3\theta(2+3\theta)\alpha^2-7\theta^2\alpha^3+\alpha^2\theta^2)}{4(3+\theta\alpha(\alpha-4))^2} \tag{3.8}$$

If the value of α is very close to one, the violator's expected profit turns out to be zero. Thus, in the world of perfect courts, the expected profit of the violator would be zero.

The non-violator does not pay any damages and thus his expected profit(eq.3.3) is:

$\Pi_{2nv}^{LP} = \pi_2(q_1, q_{2nv})$
$= q_{2nv}^{LP}(1 - q_1^{LP} - q_{2nv}^{LP})$
$= \frac{(2+\theta(-3+\alpha)\alpha)^2}{4(3+\theta\alpha(-4+\alpha))^2}$, or

$$\Pi_{2nv}^{LP} = \frac{(2+\theta(\alpha-3)\alpha)^2}{4(3+\theta\alpha(\alpha-4))^2} \tag{3.9}$$

Thus the expected profits of both duplicators depend on the parameters θ and α, that is, the probability of facing a violator and the probability of having judgement in favour of the owner of the secret. Again, no monotonic relationship exists between the expected profits of the violator and non-violator and the parameters θ and α. We now examine the equilibrium quantities and profits under the Unjust Enrichment (UE) regime of damages.

3.4.2 The Unjust Enrichment Regime

Under the UE regime of damages, the owner of the secret can recover the profits made by the violator[26]. Thus the misappropriator would need to pay all his profits

[26] Again, the formulation of the UE regime follows the literature of patent infringement (see Choi (2009)).

attributable to use of the secret to the owner of the secret[27]. The expected profit of the owner of the secret is given by:

$$\Pi_1^{UE} = \theta(\pi_1(q_1, q_{2v}) + \alpha\pi_2(q_1, q_{2v})) + (1-\theta)\pi_1(q_1, q_{2nv}) \tag{3.10}$$

With probability α, the owner of the secret expects to get damages equal to the profits of the duplicator. However, no damages are awarded if the duplicator happens to be a non-violator. The expected payoff of two kinds of duplicators are as follows:

$$\Pi_{2v}^{UE} = (1-\alpha)\pi_2(q_1, q_{2v}) \tag{3.11}$$

for the violator, and

$$\Pi_{2nv}^{UE} = \pi_2(q_1, q_{2v}) \tag{3.12}$$

for the non-violator.

Under the UE regime, the payoff of the violator and the non-violator is similar, the payoff of the violator is just scaled down by $(1-\alpha)$. Thus, given any q_1, the output choice of both the violator and the non-violator would be same. Note that when the value of α equals one, the expected profit becomes zero for the violator(eq.3.11). But the non-violator does not pay any damages and thus he earns just the duopoly profit (eq.3.12).

The equilibrium quantities of the players under the UE regime are given by[28]:

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[27]Note that under the homogenous good market, the maximum profit possible is the monopoly profit. Thus, the profit of the duplicator would make the secret owner, at the maximum, as well off as he was when there was no duplication, that is earning monopoly profit.

[28]Please refer to the Appendix (2) for calculations.

$$q_1^{UE} = \frac{1 - \theta\alpha}{3 - \theta\alpha} \tag{3.13}$$

$$q_{2v}^{UE} = \frac{1}{3 - \theta\alpha} \tag{3.14}$$

$$q_{2nv}^{UE} = \frac{1}{3 - \theta\alpha} \tag{3.15}$$

It is interesting to note that the owner of the secret produces a lower quantity as compared to both kinds of duplicators. It is in sharp contrast to the behavior of the owner of the secret under the LP regime. The intuition behind this result is as follows. The owner of the secret gets the profits of the violator in the case of the UE regime with some probability, so he internalises this information. This internalisation induces the owner of the secret to produce a lower output as compared to the standard oligopoly output. This may be thought of as an inward shift of the reaction curve of the owner of the secret. As a result, the duplicator's output is higher as compared to the standard oligopoly output (his reaction curve would shift outward). Under the LP regime the violator internalises the expected damages to be paid in form of lost profits of the owner of the secret (the monopoly profits minus the actual profits of the owner of the secret). Here, the violator produces a lower quantity as compared to the standard oligopoly output. As a result the owner of the secret produces a higher quantity (his reaction curve shifts outward) as compared to the standard oligopoly output. Thus, the owner of the secret produces a lower quantity than both the violator and the non-violator under the UE regime as compared to that under the LP regime.

The expected payoffs under the UE regime are:

The owner of the secret

We plug in the equilibrium quantities(eq.3.13,3.14,3.15) in the expected payoff function of the owner of the secret(eq.3.10).

$\Pi_1^{UE} = \theta(\pi_1(q_1, q_{2v}) + \alpha\pi_2(q_1, q_{2v})) + (1-\theta)\pi_1(q_1, q_{2nv}) = \theta[(q_1^{UE}(1 - q_1^{UE} - q_{2v}^{UE}) + \alpha q_{2v}(1 - q_1^{UE} - q_{2v}^{UE})] + (1-\theta)(q_1^{UE}(1 - q_1^{UE} - q_{2nv}^{UE})) = \frac{1}{(\theta\alpha-3)^2}$, or

$$\Pi_1^{UE} = \frac{1}{(3-\theta\alpha)^2} \tag{3.16}$$

Similarly we find the equilibrium expected profits of the violator and non violator.

The duplicator

For the violator, the expected payoff(eq.3.11) is given by

$$\Pi_{2v}^{UE} = (1-\alpha)\pi_2(q_1, q_{2v}) = \frac{1-\alpha}{(3-\theta\alpha)^2} \tag{3.17}$$

,and for the non violator(eq.3.12)

$$\Pi_{2nv}^{UE} = \pi_2(q_1, q_{2nv}) = \frac{1}{(3-\theta\alpha)^2} \tag{3.18}$$

Now, we move on to compare the two regimes in terms of quantities produced and the expected payoffs of the players.

3.4.3 The Lost Profit Vs Unjust Enrichment Regime: A comparison

Comparison between quantities under two regimes

In this section we are interested in comparing equilibrium quantities and expected profits of the players under the LP regime and the UE regime of damages.

The owner of the secret

Firstly we compare equilibrium quantities produced by the owner of the secret. The quantities produced under the LP and the UE regime are:

$q_1^{LP} = \frac{1-\theta\alpha}{3-4\theta\alpha+\theta\alpha^2}$

$q_1^{UE} = \frac{1-\theta\alpha}{3-\theta\alpha}$

We note that the owner of the secret produces a greater quantity under the LP regime as compared to that under the UE regime (Appendix 4).[29]

Similarly we can look at the quantity produced by the violator under two regimes of damages. The equilibrium quantities under two regimes are given by

$q_{2v}^{LP} = \frac{2-(1+3\theta)\alpha+2\theta\alpha^2}{6+2\theta(\alpha-4)\alpha}$

$q_{2v}^{UE} = \frac{1}{3-\theta\alpha}$

It turns out that the violator produces a lower quantity under the LP regime as compared to that under the UE regime (Appendix 5)[30].

We also investigate whether there is a difference in the quantity produced by a non-violator under two damage regimes. If yes, what is the direction of the difference? Does he produce a greater quantity under the LP regime as compared to the UE regime? The quantities, under the LP regime and the UE regime respectively, are given by

$q_{2nv}^{LP} = \frac{2+\theta(\alpha-3)\alpha}{6+2\theta(\alpha-4)\alpha}$

$q_{2nv}^{UE} = \frac{1}{3-\theta\alpha}$

As shown in Appendix 6, the non-violator too produces a greater quantity under the UE regime as compared to that under the LP regime.

Proposition 1: The owner of the secret produces a greater quantity under the LP regime whereas both kinds of duplicators produce a greater

[29] This result is summarised in Proposition 1. The intuition behind this result is presented there.

[30] This result is also summarised in Proposition 1. The intuition behind this is presented there.

quantity under the UE regime.

The intuition behind this result can be described as follows. Under the UE regime, the owner of the secret receives profits of the violator as damages with some probability. This implies that the owner of the secret has a partial ownership in the duplicator's firm. Thus, the owner of the secret internalises this information and produces a lower quantity accordingly (and allow the duplicator to produce more), which provides him higher payoff. This leads the owner of the secret to produce a quantity lower than the standard oligopoly output. Under the LP regime, however, the role reverses for the violator. The violator expects to pay the lost profits of the owner of the secret, with some probability, and hence lowers his quantity by internalising this information (so that he pays lower damages if misappropriation is proved in court). Therefore the owner of the secret produces a greater quantity under the LP regime and both kinds of duplicators produce a greater quantity under the UE regime.

It is more informative to compare the expected payoffs to the players, rather than just comparing the quantities. Thus, we look at the comparison of expected payoffs now.

Comparison between expected payoffs under two regimes

In this section we investigate the difference between expected profits of players under two regimes of damages. Under the LP regime we have:

$\Pi_1^{LP} = \frac{4-3\theta\alpha+6\theta^2(\alpha-2)\alpha^2+\theta^3\alpha^3(12-8\alpha+\alpha^2)}{4(3+\theta(\alpha-4)\alpha)^2}$, whereas the expected profit of the owner of the secret under the UE regime is given by

$\Pi_1^{UE} = \frac{1}{(\theta\alpha-3)^2}$

We are interested in comparing the expected profits of the owner of the secret under two regimes. As shown in Appendix 7, the owner of the secret gets a higher expected

payoff under the LP regime. This is quite intuitive and follows as a consequence of having a homogenous goods market. Under the homogenous goods industry, the monopoly profit is the highest profit that a firm can earn and hence the LP damages give the owner of the secret profits equal to the monopoly profit. Thus, we infer that the expected payoff of the owner of the secret is higher under the LP regime as compared to that under the UE regime.

Similarly we can see whether the violator and the non-violator earn greater profit under the LP regime as compared to that under the UE regime. The violator's expected payoffs under the LP regime and under the UE regime are given by

$\Pi_{2v}^{LP} = \frac{(1-\alpha)(4-(1+12\theta)\alpha+3\theta(2+3\theta)\alpha^2-7\theta^2\alpha^3+\alpha^2\theta^2)}{4(3+\theta\alpha(\alpha-4))^2}$, and

$\Pi_{2v}^{UE} = \frac{1-\alpha}{(\theta\alpha-3)^2}$

As shown in Appendix 8, the payoff under one regime as compared to the other for the violator can be higher or lower, depending on the values of the parameters of the model, that is, θ and α. To visualise the range of values over which the difference $(\Pi_{2v}^{LP}-\Pi_{2v}^{UE})$ is negative or positive, we draw a contour diagram which clearly separates the region where the difference is negative from the region where the difference is positive. We make a contour diagram on a 2D space assuming $\Pi_{2v}^{LP} - \Pi_{2v}^{UE} = 0$. Note that this contour represents all those points where the violator earns same level of profits under both regimes. This also gives us the range of values of parameters θ and α where the difference is positive and where it is negative. All the points above this contour represent higher profits for the violator under the LP regime and all points below this contour represent higher profits for the violator under the UE regime.

The diagram(ref. Figure 3.1) shows that the difference can be positive for a very high value of θ and correspondingly high value of α. Thus the expected payoff of the violator under the LP regime can be higher or lower than the payoff under the UE

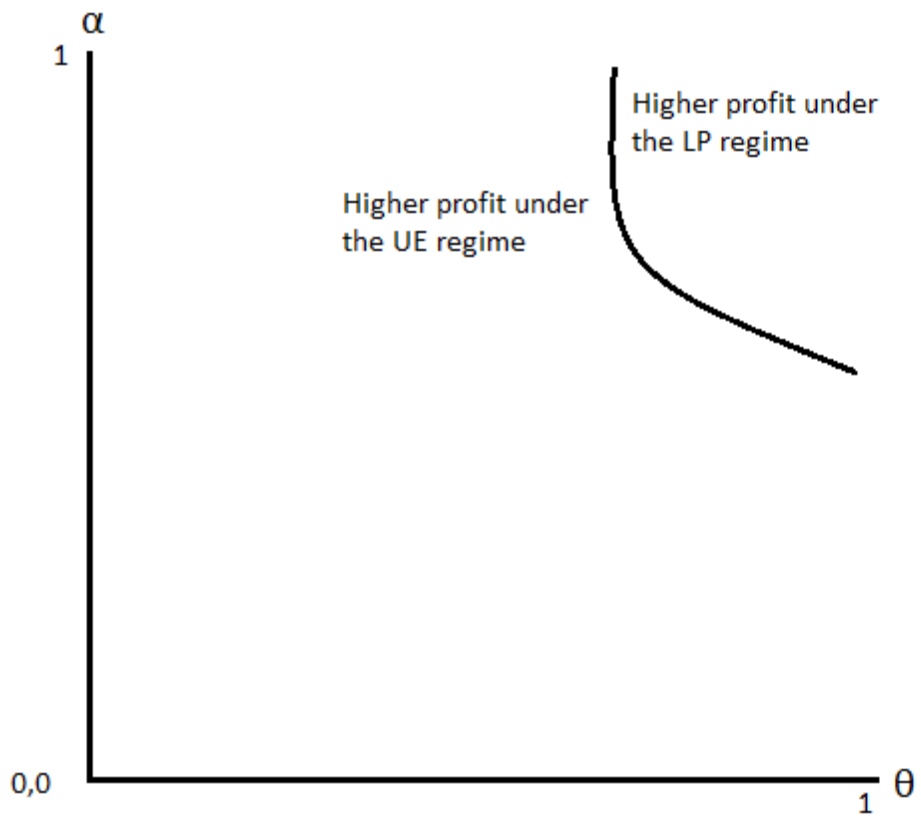

Figure 3.1: The curve showing equal profits for the violator under both damage regimes. All points above the curve represent higher profits under the LP regime, and all points below the curve represent higher profits under the UE regime.

regime depending on the values of parameters; the probability of duplicator being a violator and the probability of correct judgement, given misappropriation. It is an interesting result, as it shows that for the violator, under non-extreme situations, given by non-extreme values of the parameters, the UE regime is better.

Finally, we also look at the payoff of the non-violator under two damage regimes and investigate which gives the highest payoff to him. The expected payoffs of the non-violator under the LP regime and under the UE regime respectively are given by

$\Pi_{2nv}^{LP} = \frac{(2+\theta(\alpha-3)\alpha)^2}{4(3+\theta\alpha(\alpha-4))^2}$, and

$\Pi_{2nv}^{UE} = \frac{1}{(\theta\alpha-3)^2}$

We find that the non-violator earns a higher payoff under the UE regime (see Appendix 9). The intuition behind this is explained by the nature of information asymmetry. Since the owner of the secret does not know for sure whether the duplicator he faces is a violator or a non-violator, he behaves as if he has a partial ownership in the duplicator's firm (because, with some probability, the owner expects to receive the profits of the duplicator). This induces the owner of the secret to compete less aggressively and reduce his output level. Consequently, this allows the non-violator to increase his output level. Under the UE regime, the non-violator does not pay damages. However, the owner of the secret would have a higher output as compared to the standard oligopoly output because he does not know whether the duplicator is a non-violator or a violator[31]. This results in a higher payoff of the non-violator under the UE regime than under the LP regime.

Proposition 2: The owner of the secret is better off under the LP regime; the non-violator is better off under the UE regime whereas the violator

[31] The owner of the secret expects the duplicator to be a violator with some probability, and hence produces a higher amount. Refer to the explanation of Proposition 1 for more details.

can be better off under any of the damage regimes depending on the values of the parameters θ and α.

3.4.4 Incentives to misappropriate under different regimes of damages

Another interesting issue to investigate is which damage regime exhibit higher incentives to misappropriate a secret. To answer this question we take the difference in the relative incentives to misappropriate between two damage regimes. We calculate the difference between payoffs of the violator and the non-violator under the LP regime as well as under the UE regime and then compare them. The relative incentives to misappropriate are the difference between the payoff of the violator and the non-violator and is given by $\Pi_{2v}^{LP} - \Pi_{2nv}^{LP}$ under the LP regime and by $\Pi_{2v}^{UE} - \Pi_{2nv}^{UE}$ under the UE regime. If the difference between them turns out to be positive, i.e. $(\Pi_{2v}^{LP} - \Pi_{2nv}^{LP}) - (\Pi_{2v}^{UE} - \Pi_{2nv}^{UE}) > 0$, the incentives to misappropriate a secret, rather than discovering it independently, are higher under the LP regime as compared to that under the UE regime. We have

$$\begin{aligned}
&\Pi_{2v}^{LP} - \Pi_{2nv}^{LP} \\
&= \tfrac{(1-\alpha)(4-(1+12\theta)\alpha+3\theta(2+3\theta)\alpha^2-7\theta^2\alpha^3+\alpha^2\theta^2)}{4(3+\theta\alpha(\alpha-4))^2} - \tfrac{(2+\theta(\alpha-3)\alpha)^2}{4(3+\theta\alpha(\alpha-4))^2} \\
&= \tfrac{\alpha\left(6\theta^2\alpha^3-11\theta^2\alpha^2+\theta^2\alpha-6\theta\alpha^2+14\theta\alpha+\alpha-5\right)}{4(\theta\alpha^2-4\theta\alpha+3)^2}, \text{ or}
\end{aligned}$$

$$\Pi_{2v}^{LP} - \Pi_{2nv}^{LP} = \frac{\alpha\left(6\theta^2\alpha^3 - 11\theta^2\alpha^2 + \theta^2\alpha - 6\theta\alpha^2 + 14\theta\alpha + \alpha - 5\right)}{4\left(\theta\alpha^2 - 4\theta\alpha + 3\right)^2} \tag{3.19}$$

and, under the UE regime we have,

$$\Pi_{2v}^{UE} - \Pi_{2nv}^{UE} = \frac{1-\alpha}{(\theta\alpha-3)^2} - \frac{1}{(\theta\alpha-3)^2} = -\frac{\alpha}{(\theta\alpha-3)^2} \tag{3.20}$$

Then we take the difference between them, that is,

$$
\begin{aligned}
&(\Pi_{2v}^{LP} - \Pi_{2nv}^{LP}) - (\Pi_{2v}^{UE} - \Pi_{2nv}^{UE}) \\
&= \frac{\alpha\left(6\theta^2\alpha^3 - 11\theta^2\alpha^2 + \theta^2\alpha - 6\theta\alpha^2 + 14\theta\alpha + \alpha - 5\right)}{4(\theta\alpha^2 - 4\theta\alpha + 3)^2} - \left(-\frac{\alpha}{(\theta\alpha - 3)^2}\right) \\
&= \frac{\alpha\left(6\theta^4\alpha^5 - 11\theta^4\alpha^4 + \theta^4\alpha^3 - 42\theta^3\alpha^4 + 80\theta^3\alpha^3 - 6\theta^3\alpha^2 + 4\theta^2\alpha^4 + 59\theta^2\alpha^3 - 124\theta^2\alpha^2 + 9\theta^2\alpha - 36\theta\alpha^2 + 60\theta\alpha + 9\alpha - 9\right)}{4\left(9 - \theta^2\alpha^3 + 4\theta^2\alpha^2 + 3\theta\alpha^2 - 15\theta\alpha\right)^2},
\end{aligned}
$$

or

$$
(\Pi_{2v}^{LP} - \Pi_{2nv}^{LP}) - (\Pi_{2v}^{UE} - \Pi_{2nv}^{UE}) = \frac{\alpha\left(\begin{array}{c} 6\theta^4\alpha^5 - 11\theta^4\alpha^4 + \theta^4\alpha^3 - 42\theta^3\alpha^4 + 80\theta^3\alpha^3 - 6\theta^3\alpha^2 + 4\theta^2\alpha^4 \\ +59\theta^2\alpha^3 - 124\theta^2\alpha^2 + 9\theta^2\alpha - 36\theta\alpha^2 + 60\theta\alpha + 9\alpha - 9 \end{array}\right)}{4\left(9 - \theta^2\alpha^3 + 4\theta^2\alpha^2 + 3\theta\alpha^2 - 15\theta\alpha\right)^2} \tag{3.21}
$$

Incentives to misappropriate may be higher or lower under one of the damage regimes as compared to the other depending on the values of parameters. For instance, consider a combination of parameters such that $(\theta, \alpha) = (0.2, 0.5)$. With these values of parameters, the difference, $(\Pi_{2v}^{LP} - \Pi_{2nv}^{LP}) - (\Pi_{2v}^{UE} - \Pi_{2nv}^{UE})$ is negative whereas for values $(\theta, \alpha) = (0.5, 0.5)$, the difference is positive. Thus, the incentives to misappropriate the secret rather than discovering it independently may be higher under the LP regime for relatively higher values of θ and α, and vice versa. We draw this difference in a contour diagram(ref. Figure 3.2), keeping the difference equal to zero, so that for all the values above the curve, the difference is positive and for all the values below the curve, the difference is negative.

From the diagram it is clear that when both the parameters, θ and α, are low so as to be in the region below and to the left of the curve, the incentives to misappropriate under the UE regime are higher as compared to that under the LP regime. On the

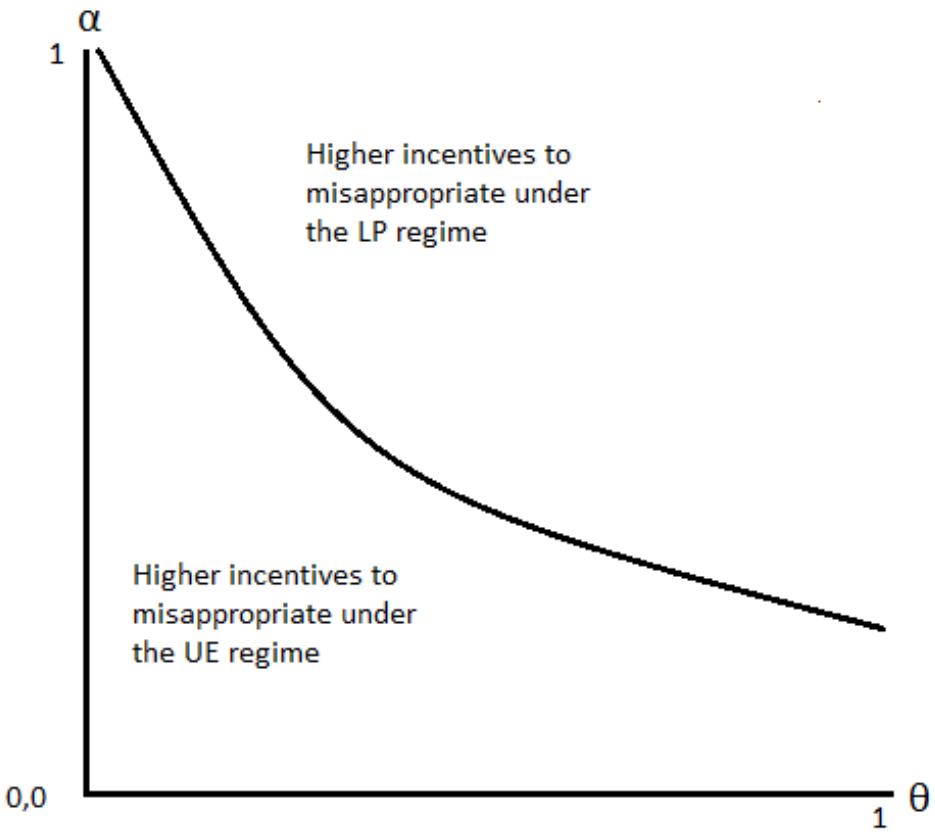

Figure 3.2: The curve showing equal incentives to misappropriate under the LP as well as the UE regime. For all points above the curve, the LP regime provides higher incentives to misappropriate a secret, converse is true for all points below the curve.

other hand, for the points above and to the right of the curve, the LP regime exhibit higher incentives to misappropriate the secret as compared to the UE regime. This has important implications for real world markets. Markets that are characterised by high incidence of trade secrets theft (relatively high θ), even with a relatively low enforcement by courts, meaning a relatively lower α, the LP regime of damages provide higher incentives to misappropriate a secrets compared to the UE regime.

Proposition 3: Incentives to misappropriate under the LP regime are higher as compared to that under the UE regime for sufficiently high values of parameters θ and α. The reverse holds for sufficiently low values of parameters θ and α.

If the value of α is very low, with any level of θ, the UE regime provides higher incentives to misappropriate. If courts make correct decisions about the guilt of a violator half of the times, i.e. $\alpha = 0.5$, the LP regime provides higher incentives to misappropriate for a big range of values of θ[32]. These insights can be very helpful in analysing real world situations and can help decide a particular damage regime for some markets.

3.4.5 Welfare under different damage regimes

In this section we investigate which of the damage regimes exhibits higher welfare. We calculate the welfare under different regimes and compare which of the damage regimes generates higher welfare. Total social welfare (SW) may be defined to be the sum of consumer surplus, producer surplus, that is profits of the innovator and the duplicator.

---

[32]It may be noted that θ is assumed to be a fixed belief, that is, it is not affected by α.
Further, the quantity actually produced by the duplicator can signal the duplicator's type, however, this piece of information can not be used in court by assumption.

$SW = ConsumerSurplus + ProducerSurplus$

Since we do not know whether the duplicator would be a misappropriator or not, we do not know what would be the quantity produced by the duplicator. It is known, however, that with probability θ, the duplicator would be a misappropriator of the secret, and with probability $(1-\theta)$, he would be an independent researcher. Thus we can write the expected quantity as $q_2 = \theta q_{2v} + (1-\theta)q_{2nv}$.

Note that the maximisation of the social welfare is equivalent to minimisation of the social loss, or deadweight loss. The total area under the demand curve is divided among the consumer surplus, the producers' surplus and the deadweight loss. Hence we can directly compare the deadweight loss under the two damage regimes, and investigate which damage regime produces higher welfare.

The demand function is linear here, $p = 1 - q_1 - q_2$. We can also write $p = 1 - Q$, where $Q = q_1 + q_2$.

Since the demand function is linear, the deadweight loss area is a right angle triangle, with $1-Q$ as base and the price as height (p). So we can write the deadweight loss as

$$DL = \frac{1}{2}(1-Q)p = \frac{1}{2}(1-Q)^2 \tag{3.22}$$

We now calculate the deadweight loss under two damage regimes and compare them. However, we need to know the expected total quantities under two regimes. Total expected quantities under the LP and the UE regimes are calculated below.

Under the LP regime, we have

$q_1^{LP} = \frac{1-\theta\alpha}{3-4\theta\alpha+\theta\alpha^2}$

$q_2^{LP} = \theta q_{2v}^{LP} + (1-\theta)q_{2nv}^{LP}$

$= \theta(\frac{2-(1+3\theta)\alpha+2\theta\alpha^2}{6+2\theta(\alpha-4)\alpha}) + (1-\theta)(\frac{2+\theta(\alpha-3)\alpha}{6+2\theta(\alpha-4)\alpha})$

$= \frac{1}{2\theta\alpha^2-8\theta\alpha+6}\left(\theta^2\alpha^2+\theta\alpha^2-4\theta\alpha+2\right)$

Thus the total quantity can be written as

$Q^{LP} = q_1^{LP} + q_2^{LP} = \frac{1-\theta\alpha}{3-4\theta\alpha+\theta\alpha^2} + \frac{1}{2\theta\alpha^2-8\theta\alpha+6}\left(\theta^2\alpha^2+\theta\alpha^2-4\theta\alpha+2\right)$

$= \frac{\theta^2\alpha^2+\theta\alpha^2-6\theta\alpha+4}{2\theta\alpha^2-8\theta\alpha+6}$, or

$$Q^{LP} = \frac{\theta^2\alpha^2+\theta\alpha^2-6\theta\alpha+4}{2\theta\alpha^2-8\theta\alpha+6} \tag{3.23}$$

Under the UE regime, we have

$q_1^{UE} = \frac{\theta\alpha-1}{\theta\alpha-3}$

$q_2^{UE} = \theta q_{2v}^{UE} + (1-\theta)q_{2nv}^{UE} = \frac{1}{3-\theta\alpha}$

Thus the total quantity can be written as

$Q^{UE} = q_1^{UE} + q_2^{UE}$

$= \frac{\theta\alpha-1}{\theta\alpha-3} + \frac{1}{3-\theta\alpha}$

$= \frac{2-\theta\alpha}{3-\theta\alpha}$, or

$$Q^{UE} = \frac{2-\theta\alpha}{3-\theta\alpha} \tag{3.24}$$

By comparing Q^{LP} and Q^{UE}, we recognize that the quantities are not same under two regimes and hence the welfare must be different under two damage regimes. We plot the quantities under different damage regimes (Figure 3.3), fixing the value of $\alpha = 0.5$[33].

We now calculate the deadweight loss associated with the LP regime and the UE regime and compare them.

From (3.22), we can compare the deadweight losses as follows.

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[33]Note that for any other value of α the result remains the same. The value 0.5 implies that courts make correct judgement 50% of the times.

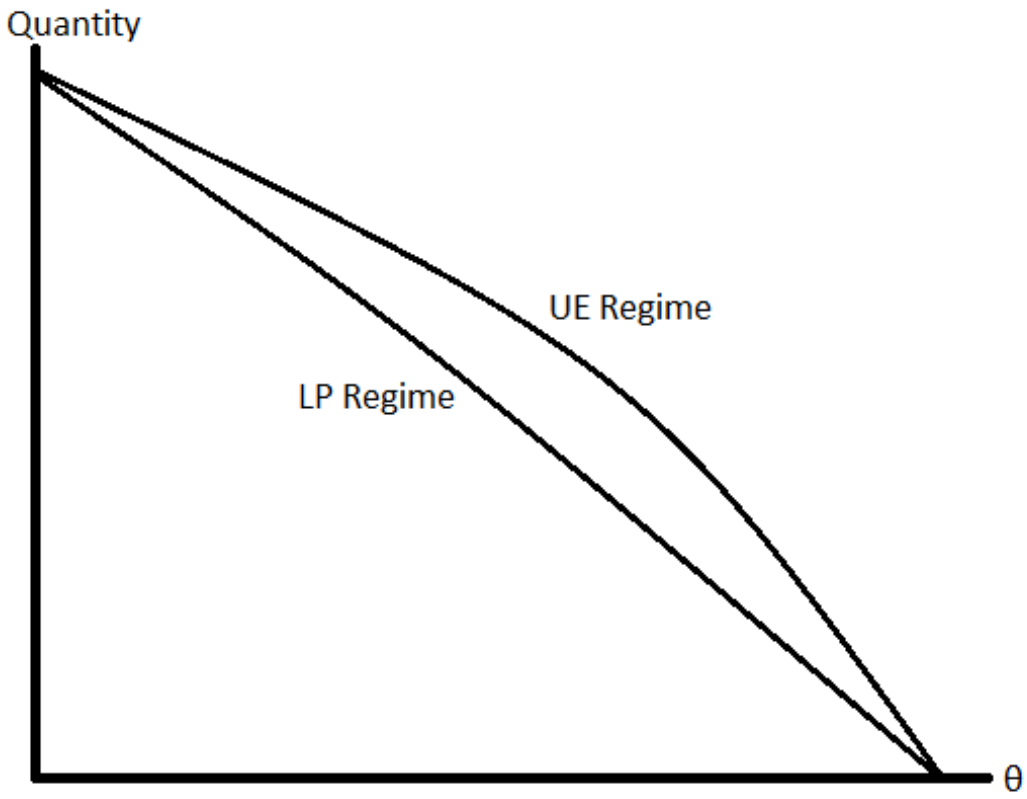

Figure 3.3: Total quantities produced under two regimes.

$$DL^{LP} = \frac{1}{2}(1 - Q^{LP})^2$$

$$DL^{UE} = \frac{1}{2}(1 - Q^{UE})^2$$

$$DL^{LP} > DL^{UE} \longleftrightarrow \frac{1}{2}(1 - Q^{LP})^2 > \frac{1}{2}(1 - Q^{UE})^2, \text{ or,}$$

$$1 - Q^{LP} > 1 - Q^{UE}, \text{ or,}$$

$$Q^{UE} > Q^{LP} \tag{3.25}$$

Therefore the deadweight loss under the LP regime is higher than that under the UE regime if the quantity supplied under the UE regime is higher than the quantity under the LP regime. We can just check whether condition (3.25) is satisfied or not. We find that the total production under the UE regime is higher[34] (Appendix 10), implying that the deadweight loss under the LP regime is higher relative to that under the UE regime (refer to 3.25). In sum, the welfare and the industry output, both are higher under the UE regime.

Proposition 4: The welfare and the industry output are higher under the UE regime than under the LP regime.

[34]Note that Figure 3.3 presents total quantities under two regimes keeping $\alpha = 0.5$. However, total production under the UE regime is higher than under the LP regime for all values of the parameters α and θ.

3.5 Conclusion

This chapter looks at two central damage regimes for misappropriation of a trade secret, the LP regime and the UE regime. A simple model of asymmetric information is developed where the trade owner of the secret does not know whether the duplicator has developed the competing product by independent research or has misappropriated the secret somehow. It is shown that the owner of the secret is better off under the LP regime whereas the duplicator who develops his product by independent research is better off under the UE regime. However, the duplicator who misappropriated the secret may be better off or worse off in any of the damage regimes, depending on the values that parameters take. The incentives to misappropriate are greater or lower under the LP regime as compared to that under the UE regime depending on the parameters of the model. The social welfare under the UE regime is higher than that under the LP regime.

3.6 Appendix

(1) **Equilibrium quantities under the LP regime of damages:**

If there was no duplicator, the owner of the secret would have been a monopolist, with the demand function $p = 1 - q$. The monopolist maximises $\pi_m = pq = q(1 - q)$, which gives equilibrium quantity $q_m = \frac{1}{2}$, and equilibrium profit $\pi_m = \frac{1}{4}$. However, with the entry of the second firm in the market, the owner of the secret loses his monopoly and earns the duopoly profit. The firms are assumed to compete in Cournot fashion, that is, they compete in quantities.

We have:

$\Pi_1^{LP} = \theta((1 - \alpha)\pi_1(q_1, q_{2v}) + \alpha\pi_m) + (1 - \theta)\pi_1(q_1, q_{2nv})$

$= \theta((1-\alpha)q_1(1-q_1-q_{2v}) + \frac{\alpha}{4}) + (1-\theta)(q_1(1-q_1-q_{2nv}))$.

The owner of the secret chooses the quantity by maximising Π_1^{LP} w.r.t. q_1,the first order condition is given by $\frac{\partial \Pi_1^{LP}}{\partial q_1} = 0$. From the first order condition, we derive the best response function of the owner of the secret, given by $q_1 = \frac{\theta\alpha+\theta q_{2v}-\theta\alpha q_{2v}+q_{2nv}-\theta q_{2nv}-1}{2(\theta\alpha-1)}$.

The expected payoff of the violator is given by

$\Pi_{2v}^{LP} = \pi_2(q_1, q_{2v}) - \alpha(\pi_m - \pi_1(q_1, q_{2v}))$

$= q_2(1-q_1-q_{2v}) - \alpha(\frac{1}{4} - q_1(1-q_1-q_{2v}))$.

The violator maximises his expected payoff Π_{2v}^{LP} w.r.t. q_{2v}, which gives the first order condition as $\frac{\partial \Pi_{2v}^{LP}}{\partial q_{2v}} = 0$. The best response function can thus be calculated as $q_{2v} = \frac{1-(\alpha+1)q_1}{2}$. The non-violator discovers the secret formula by independent research, hence does not pay any damage and thus damages do not appear in his expected payoff function. His payoff function is given by

$\Pi_{2nv}^{LP} = \pi_2(q_1, q_{2nv})$

$= q_{2nv}(1-q_1-q_{2nv})$.

The first order condition is given by $\frac{\partial \Pi_{2nv}^{LP}}{\partial q_{2nv}} = 0$ and the best response function is simply $q_{2nv} = \frac{1-q_1}{2}$.

Thus we have three best response functions here,

$q_1 = \frac{\theta\alpha+\theta q_{2v}-\theta\alpha q_{2v}+q_{2nv}-\theta q_{2nv}-1}{2(\theta\alpha-1)}$,

$q_{2v} = \frac{1-(\alpha+1)q_1}{2}$,

$q_{2nv} = \frac{1-q_1}{2}$

for the owner of the secret, the violator and the non-violator respectively. By solving these three best responses, we can derive the equilibrium quantities of the owner of the secret, the violator and the non-violator as:

$$q_1^{LP} = \frac{1-\theta\alpha}{3-4\theta\alpha+\theta\alpha^2}$$

$$q_{2v}^{LP} = \frac{2-(1+3\theta)\alpha+2\theta\alpha^2}{6+2\theta(\alpha-4)\alpha}$$

$$q_{2nv}^{LP} = \frac{2+\theta(\alpha-3)\alpha}{6+2\theta(\alpha-4)\alpha}$$

We may want to investigate who supplies a greater quantity in this market, the owner of the secret or the duplicator? For instance, if the duplicator is a violator, who produces a greater quantity under the LP regime, the owner of the secret or the duplicator? To see this, we look at the difference between the quantity produced by the violator from the quantity produced by the owner of the secret. We have $q_1^{LP} - q_{2v}^{LP} = \frac{1}{2}\frac{\alpha(\theta-2\theta\alpha+1)}{3-4\theta\alpha+\theta\alpha^2}$, which is positive for all values of θ and α such that $0 < \theta, \alpha < 1$. Thus the owner of the secret produces a greater quantity as compared to a violator. We can also compare the quantity of the owner of the secret with the quantity of non-violator. Again, we look at the difference between the quantity produced by the owner of the secret and the quantity produced by the non-violator. We have $q_1^{LP} - q_{2nv}^{LP} = \frac{1}{2}\frac{\theta\alpha(1-\alpha)}{3-4\theta\alpha+\theta\alpha^2} > 0$ for $0 < \theta, \alpha < 1$. Thus the owner of the secret produces more as compared to the duplicator, no matter whether it happens to be a violator or non-violator. Note that all these quantities depend on two parameters, θ, the proportion of violators, or in other words, the probability that the duplicator has misappropriated the secret, and α, the probability that courts punish the misappropriator.

We can also investigate whether the violator produces a lower quantity than the non-violator. We have $q_{2v}^{LP} - q_{2nv}^{LP} = \frac{2-(1+3\theta)\alpha+2\theta\alpha^2}{6+2\theta(\alpha-4)\alpha} - \frac{2+\theta(\alpha-3)\alpha}{6+2\theta(\alpha-4)\alpha} = \frac{\alpha(\theta\alpha-1)}{2(\theta\alpha^2-4\theta\alpha+3)} < 0$ for all values of $0 < \theta, \alpha < 1$. Thus, the violator produces a lower quantity relative to a non-violator, in view of payment of potential damages.

(2) **Equilibrium quantities under the UE regime of damages:**

To find equilibrium quantities produced by the players under the UE regime, we plug in the market demand function in this set up. The market demand is given by $p = 1 - (q_1 + q_2)$. The owner of the secret maximises his expected profit Π_1^{UE} w.r.t q_1. Thus we have

$\Pi_1^{UE} = \theta(\pi_1(q_1, q_{2v}) + \alpha\pi_2(q_1, q_{2v})) + (1-\theta)\pi_1(q_1, q_{2nv})$

$= \theta[(q_1(1 - q_1 - q_{2v}) + \alpha q_{2v}(1 - q_1 - q_{2v})] + (1-\theta)(q_1(1 - q_1 - q_{2nv}))$

The first order condition is given by $\frac{\partial \Pi_1^{UE}}{\partial q_1} = \theta(1 - 2q_1 - q_{2v} - \alpha q_{2v}) + (1-\theta)(1 - 2q_1 - q_{2nv}) = 0$. We can then derive the best response function of the secret holder as $q_1 = \frac{1}{2}(1 - \theta q_{2v} - \theta\alpha q_{2v} - q_{2nv} + \theta q_{2nv})$

$= \frac{1}{2}(1 - (1+\alpha)\theta q_{2v} - (1-\theta)q_{2nv})$.

The expected payoff of the violator is given by $\Pi_{2v}^{UE} = (1-\alpha)\pi_2(q_1, q_{2v})$

$= (1-\alpha)q_{2v}(1 - q_1 - q_{2v})$.

The maximisation condition is $\frac{\partial \Pi_{2v}^{UE}}{\partial q_{2v}} = (1-\alpha)(1 - q_1 - 2q_{2v}) = 0$. Given $\alpha < 1$, we can write the best response function of the misappropriator duplicator as $q_{2v} = \frac{1-q_1}{2}$. The non-violator simply maximises $\Pi_{2v}^{UE} = \pi_2(q_1, q_{2nv}) = q_{2nv}(1 - q_1 - q_{2nv})$ w.r.t q_{2nv}. From first order condition $\frac{\partial \Pi_{2nv}^{UE}}{\partial q_{2nv}} = 0$, we derive the best response function as $q_{2nv} = \frac{1-q_1}{2}$.

Thus we have three best response functions here,

$q_1 = \frac{1}{2}(1 - (1+\alpha)\theta q_{2v} - (1-\theta)q_{2nv})$,

$q_{2v} = \frac{1-q_1}{2}$,

$q_{2nv} = \frac{1-q_1}{2}$

for the owner of the secret, the violator and the non-violator respectively under the UE regime of damages. By solving these three best responses, we derive the equilibrium quantities of the owner of the secret, the violator and the non-violator as:

$$q_1^{UE} = \frac{1-\theta\alpha}{3-\theta\alpha}$$

$$q_{2v}^{UE} = \frac{1}{3-\theta\alpha}$$

$$q_{2nv}^{UE} = \frac{1}{3-\theta\alpha}$$

Again, we investigate who produces a greater quantity in equilibrium under the UE regime, the owner of the secret or the duplicator. The quantity produced by the duplicator is same under the UE regime independent of his type, that is, both kinds of duplicators produce the same quantity in equilibrium. We have $q_1^{UE} - q_{2v}^{UE} = q_1^{UE} - q_{2nv}^{UE} = \frac{1-\theta\alpha}{3-\theta\alpha} - \frac{1}{3-\theta\alpha} = \theta\frac{\alpha}{\theta\alpha-3} < 0$, which implies that the quantity produced by the owner of the secret is lower than the quantity produced by the violator, or the non-violator under the UE regime. This is an interesting result. Under the LP regime, the owner of the secret supplies a higher quantity in the market than the duplicator while under the UE regime, the duplicator, whether violator or not, produces a higher quantity as compared to the owner of the secret.

(3) **How to sign a quadratic and cubic function?:**

Suppose we have a quadratic function of the following form:

$$f(x) = ax^2 + bx + c$$

where a, b, c are parameters.

i) If $b^2 - 4ac = 0$, we have the "double root" case with a single real root, $x = \frac{-b}{2a}$. In this case, we have $ax^2 + bx + c = a(x + \frac{b}{2a})^2$, and the function $f(x)$ has the sign of

the parameter a.

ii) If $b^2 - 4ac > 0$, we have two distinct roots of the function $f(x)$. We have $ax^2 + bx + c = a(x - x_1)(x - x_2)$, where x_1 and x_2 are the two real roots, $x_1 < x_2$. It is easy to note that $(x - x_1)(x - x_2)$ is always positive for $x < x_1$ and when $x > x_2$. However it is always negative for $x_1 < x < x_2$. Therefore $f(x)$ has the same sign as of parameter a when $x < x_1$ or $x > x_2$, and has the sign opposite of parameter a when $x_1 < x < x_2$.

iii) If $b^2 - 4ac < 0$, we have complex roots, and the sign of $f(x)$ is same as that of a.

In a similar fashion, we have three roots in the case of a cubic function, which draw the area where the function takes positive or negative values. Thus we can sign a cubic function easily.

(4) **The quantity comparison of the owner of the secret between two regimes:**

To compare them, we take their difference, $q_1^{LP} - q_1^{UE} = \frac{1-\theta\alpha}{3-4\theta\alpha+\theta\alpha^2} - \frac{1-\theta\alpha}{3-\theta\alpha}$ $= \frac{\theta\alpha(\alpha-3)(\theta\alpha-1)}{9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha}$, or

$$q_1^{LP} - q_1^{UE} = \frac{\theta\alpha\,(\alpha-3)\,(\theta\alpha-1)}{9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha} \tag{3.26}$$

The sign of eq. (3.26) depends on the sign of the denominator because for all values of $0 < \theta, \alpha < 1$, the numerator is positive. We have

$$q_1^{LP} - q_1^{UE} = \frac{\overbrace{\theta\alpha}^{+ve}\ \overbrace{(3-\alpha)}^{+ve}\overbrace{(1-\theta\alpha)}^{+ve}}{\underbrace{(4\alpha^2-\alpha^3)\theta^2+(3\alpha^2-15\alpha)\theta+9}_{Quadratic\ function\ of\ \ \theta}} \tag{3.27}$$

We have written the denominator as a quadratic function of θ to sign the denomi-

nator (See Appendix (3)). This function has two real roots of θ in terms of α, $\theta_1 = \frac{3}{\alpha}$ and $\theta_2 = \frac{3}{\alpha(4-\alpha)}$. Both of the roots are positive and higher than 1 for the valid values of parameter α, with $\theta_1 > \theta_2$. The sign of the denominator (a quadratic function) depends on the interval determined by the factors and the sign of the term with θ^2, which is $4\alpha^2 - \alpha^3 = 4\alpha^2(1-\alpha) > 0$ for all valid values of α. It turns out that the sign of the denominator is positive for all values below θ_2 and all values above θ_1; and negative for all values between θ_1 and θ_2. The range of values of interest to us is the interval between 0 and 1. Thus we note that the sign of the denominator is positive here, and hence (3.26) turns out to be positive. In other words, the owner of the secret produces a greater quantity under the LP regime as compared to that under the UE regime.

(5) **The violator's quantity comparison between two regimes:**

We take their difference as $q_{2v}^{LP} - q_{2v}^{UE} = \frac{2-(1+3\theta)\alpha+2\theta\alpha^2}{6+2\theta(-4+\alpha)\alpha} - \frac{1}{3-\theta\alpha}$

$= -\frac{1}{2}\alpha\frac{2\theta^2\alpha^2-3\theta^2\alpha-5\theta\alpha+3\theta+3}{9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha}$, or

$$q_{2v}^{LP} - q_{2v}^{UE} = -\frac{1}{2}\alpha\frac{2\theta^2\alpha^2 - 3\theta^2\alpha - 5\theta\alpha + 3\theta + 3}{9 - \theta^2\alpha^3 + 4\theta^2\alpha^2 + 3\theta\alpha^2 - 15\theta\alpha} \tag{3.28}$$

The eq.(3.28) can be re-written as quadratic functions in both numerator and the denominator (refer to eq.3.29). We have

$$q_{2v}^{LP} - q_{2v}^{UE} = \frac{1}{2}\alpha\frac{(3\alpha - 2\alpha^2)\theta^2 + (5\alpha - 3)\theta - 3}{(4\alpha^2 - \alpha^3)\theta^2 + (3\alpha^2 - 15\alpha)\theta + 9} \tag{3.29}$$

Note that the denominator of eq.(3.29) is the same as that of eq.(3.27). We already know that the sign of the denominator is positive, as found before. Thus the sign of function depends on the sign of the numerator. We can sign the numerator in the similar fashion by finding out the roots of θ in terms of α. We get two real roots of

the function $(3\alpha - 2\alpha^2)\theta^2 + (5\alpha - 3)\theta - 3$ as $\theta_1 = \frac{1}{\alpha}$ and $\theta_2 = \frac{3}{2\alpha - 3}$. It is easy to check that $\theta_1 > \theta_2$ for all valid values of α; $0 < \alpha < 1$. Further the minimum value of θ_1 is 1 in limit, and the minimum and the maximum values of θ_2 are -3 and -1 in limit. The sign of the numerator depends on the interval and the sign of the term with θ^2 (given by $3\alpha - 2\alpha^2 = \alpha(3 - 2\alpha) > 0$). This quadratic function is positive (that is, the same sign as that of $(3\alpha - 2\alpha^2)$) for all values of $\theta > \theta_1$ and $\theta < \theta_2$ and negative for the range $\theta_1 > \theta > \theta_2$. We know that θ actually lies between θ_1 and θ_2 for all $\alpha; 0 < \alpha < 1$, thus the function $(3\alpha - 2\alpha^2)\theta^2 + (5\alpha - 3)\theta - 3$ is negative here. It implies that the whole expression is negative; therefore the violator produces a lower quantity under the LP regime as compared to that under the UE regime.

(6) **The non-violator's quantity comparison between two regimes:**

The difference between the quantity under the LP regime and the UE regime is $q_{2nv}^{LP} - q_{2nv}^{UE} = \frac{2+\theta(\alpha-3)\alpha}{6+2\theta(\alpha-4)\alpha} - \frac{1}{3-\theta\alpha}$

$= \frac{\theta\alpha(\alpha-3)(1-\theta\alpha)}{2(9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha)}$, or

$$q_{2nv}^{LP} - q_{2nv}^{UE} = \frac{\theta\alpha\,(\alpha-3)\,(1-\theta\alpha)}{2(9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha)} \tag{3.30}$$

Eq.(3.30) can also be written as eq.(3.31) which is easier to sign.

$$q_{2nv}^{LP} - q_{2nv}^{UE} = \frac{\overbrace{\theta\alpha}^{+ve}\ \overbrace{(\alpha-3)}^{-ve}\overbrace{(1-\theta\alpha)}^{+ve}}{2\underbrace{((4\alpha^2-\alpha^3)\theta^2+(3\alpha^2-15\alpha)\theta+9)}_{Quadratic\ function\ of\ \ \theta}} \tag{3.31}$$

It is clear from eq.(3.31) that the sign of the whole expression is negative because of one negative term $(\alpha - 3)$. Note that the denominator is the same as in eq.(3.27) and we have already proved that this is positive. Thus the non-violator produces a

higher quantity under the UE regime than under the LP regime.

(7) **Expected payoff of the owner of the secret under two regimes:**

Reducing the payoff under the UE regime from that under the LP regime, we get:

$\Pi_1^{LP} - \Pi_1^{UE} = \frac{4-3\theta\alpha+6\theta^2(-2+\alpha)\alpha^2+\theta^3\alpha^3(12-8\alpha+\alpha^2)}{4(3+\theta(\alpha-4)\alpha)^2} - \frac{1}{(\theta\alpha-3)^2}$

$= \frac{\theta\alpha(\theta\alpha-1)^2\left(\theta^2\alpha^4-8\theta^2\alpha^3+12\theta^2\alpha^2-4\theta\alpha^3+38\theta\alpha^2-60\theta\alpha-24\alpha+45\right)}{4\left(9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha\right)^2}$, or

$$\Pi_1^{LP}-\Pi_1^{UE} = \frac{\theta\alpha\left(\theta\alpha-1\right)^2\left(\theta^2\alpha^4-8\theta^2\alpha^3+12\theta^2\alpha^2-4\theta\alpha^3+38\theta\alpha^2-60\theta\alpha-24\alpha+45\right)}{4\left(9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha\right)^2} \tag{3.32}$$

Eq.(3.32) can be rewritten as

$$\Pi_1^{LP}-\Pi_1^{UE} = \frac{\overbrace{\theta\alpha}^{+ve}\overbrace{\left(\theta\alpha-1\right)^2}^{+ve}\overbrace{\left((\alpha^4-8\alpha^3+12\alpha^2)\theta^2+(38\alpha^2-4\alpha^3-60\alpha)\theta+45-24\alpha\right)}^{Quadratic\ function\ of\ \ \theta}}{\underbrace{4\left(9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha\right)}_{+ve}} \tag{3.33}$$

Note that the sign of the expression in eq.(3.33) depends on the sign of the quadratic function of θ because all other terms are positive. To know the sign of the quadratic function, we follow the same procedure as before. We find out the factors of θ in terms of α. By solving this quadratic function, we get two real factors;

$\theta_1 = \frac{13\alpha-19\alpha^2+2\alpha^3-2\sqrt{90\alpha^2-123\alpha^3+61\alpha^4-13\alpha^5+\alpha^6}}{12\alpha^2-8\alpha^3+\alpha^4}$, and

$\theta_2 = \frac{13\alpha-19\alpha^2+2\alpha^3+2\sqrt{90\alpha^2-123\alpha^3+61\alpha^4-13\alpha^5+\alpha^6}}{12\alpha^2-8\alpha^3+\alpha^4}$

where $\theta_1 < \theta_2$. Again we find out that the minimum value that θ_1 takes is higher than 1 for values of $\alpha; 0 < \alpha < 1$ and thus the sign of the quadratic function would be same as the sign of the term with θ^2, which is $\alpha^4-8\alpha^3+12\alpha^2 = \alpha^2(\alpha^2-8\alpha+12) > 0$ for all $\alpha; 0 < \alpha < 1$. Thus the sign of the whole expression in eq.(3.33) is positive,

implying that the expected profit of the owner of the secret is higher under the LP regime as compared to that under the UE regime.

(8) **Expected payoff of the violator between two regimes:**

To know which one is higher, we take their difference as, $\Pi_{2v}^{LP} - \Pi_{2v}^{UE}$

$= \frac{(1-\alpha)(4-(1+12\theta)\alpha+3\theta(2+3\theta)\alpha^2-7\theta^2\alpha^3+\alpha^2\theta^2)}{4(3+\theta\alpha(-4+\alpha))^2} - \frac{1-\alpha}{(\theta\alpha-3)^2}$

$= \frac{\alpha(\alpha-1)\left(7\theta^4\alpha^4-10\theta^4\alpha^3-48\theta^3\alpha^3+72\theta^3\alpha^2+4\theta^2\alpha^3+68\theta^2\alpha^2-102\theta^2\alpha-36\theta\alpha+36\theta+9\right)}{4\left(9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha\right)^2}$, or

$$\Pi_{2v}^{LP} - \Pi_{2v}^{UE} = \frac{\alpha(\alpha-1)\left(7\theta^4\alpha^4 - 10\theta^4\alpha^3 - 48\theta^3\alpha^3 + 72\theta^3\alpha^2 + 4\theta^2\alpha^3 + 68\theta^2\alpha^2 - 102\theta^2\alpha - 36\theta\alpha + 36\theta + 9\right)}{4\left(9 - \theta^2\alpha^3 + 4\theta^2\alpha^2 + 3\theta\alpha^2 - 15\theta\alpha\right)^2} \tag{3.34}$$

We can draw this as a 3D diagram(ref. Figure3.4) again.

We observe from Figure 3.4 that the difference can be both positive and negative depending on the values of the parameters θ and α. For instance, for combination of $(\theta, \alpha) = (0.95, 0.80)$, the difference $\Pi_{2v}^{LP} - \Pi_{2v}^{UE}$, is positive. In fact for a range of high values of parameters θ and α, the violator earns higher profits under the LP regime as compared to that under the UE regime. But for smaller values, for eg. $(\theta, \alpha) = (0.5, 0.5)$ the difference $\Pi_{2v}^{LP} - \Pi_{2v}^{UE}$ is negative, implying that the violator earns a lower profit under the LP regime as compared to that under the UE regime.

(9) **Expected payoff of the non-violator under two regimes:**

The difference between two payoffs is given by:

$\Pi_{2nv}^{LP} - \Pi_{2nv}^{UE} = \frac{(2+\theta(-3+\alpha)\alpha)^2}{4(3+\theta\alpha(-4+\alpha))^2} - (\frac{1}{(-3+\theta\alpha)^2})$

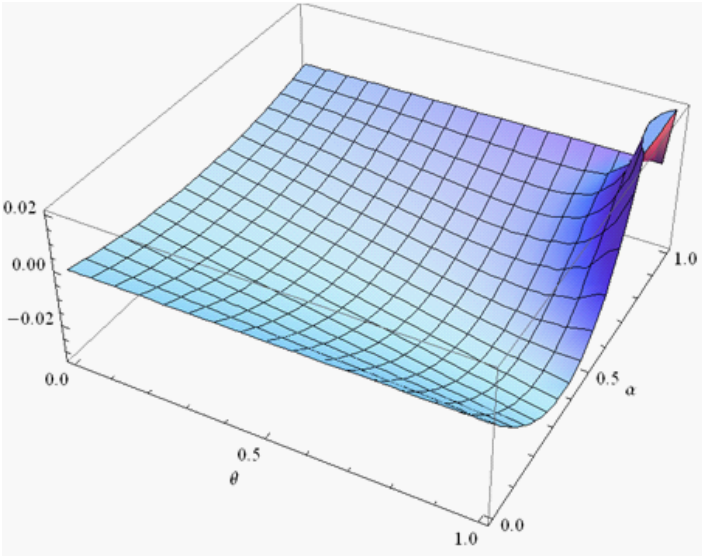

Figure 3.4: The expected profit of the violator duplicator under the LP regime minus that under the UE regime

$$= \frac{\theta\alpha(\alpha-3)\left(\theta^3\alpha^4-3\theta^3\alpha^3-6\theta^2\alpha^3+22\theta^2\alpha^2+5\theta\alpha^2-31\theta\alpha+12\right)}{4\left(9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha\right)^2}, \text{ or}$$

$$\Pi_{2nv}^{LP} - \Pi_{2nv}^{UE} = \frac{\overbrace{\theta\alpha}^{+ve}\overbrace{(\alpha-3)}^{-ve}\overbrace{\left((\alpha^4-3\alpha^3)\theta^3+(22\alpha^2-6\alpha^3)\theta^2+(5\alpha^2-31\alpha)\theta+12\right)}^{Cubic\ function\ of\ \theta}}{\underbrace{4\left(9-\theta^2\alpha^3+4\theta^2\alpha^2+3\theta\alpha^2-15\theta\alpha\right)^2}_{+ve}} \tag{3.35}$$

Note that the sign of (3.35) would depend on the cubic function of θ because we already know the signs of other terms. If we find that the sign of the cubic function is positive, then we can be sure that the difference is negative, because of the term $(\alpha-3)$, which is negative. We solve the cubic function $(\alpha^4-3\alpha^3)\theta^3+(22\alpha^2-6\alpha^3)\theta^2+(5\alpha^2-31\alpha)\theta+12=0$ and find the factors of this equation. We get three real factors, as, $\theta_1 = \frac{1}{\alpha}; \theta_2 = \frac{5\alpha^2-19\alpha-\alpha\sqrt{217-142\alpha+25\alpha^2}}{2(\alpha^3-3\alpha^2)}; \theta_3 = \frac{5\alpha^2-19\alpha+\alpha\sqrt{217-142\alpha+25\alpha^2}}{2(\alpha^3-3\alpha^2)}$. The minimum

values of all the factors for $0 < \alpha < 1$ are above 1, and thus the sign of the cubic function for all the values of θ lower than 1 would be same sign. Thus we can just check the sign of the cubic function for any value of $0 < \theta, \alpha < 1$, which turns out to be positive. Hence, the sign of the expression in (3.35) is negative, implying that the non-violator earns a higher profit under the UE regime as compared to that under the LP regime. Thus the duplicator who discovers the secret independently earns a higher payoff under the UE regime.

(10) **Total Production under two damage regimes:**

We have

$$Q^{UE} - Q^{LP} = \frac{1}{2} \underbrace{\frac{\overbrace{\theta\alpha^2}^{+ve}\overbrace{(1-\theta)}^{+ve}\overbrace{(1-\theta\alpha)}^{+ve}}{(4\alpha^2 - \alpha^3)\theta^2 + (3\alpha^2 - 15\alpha)\theta + 9}}_{Quadratic\ function\ of\ \ \theta} \tag{3.36}$$

Note that all the terms in the numerator in (3.36) are positive and in the denominator we have the quadratic function of θ, which is already proved to be positive in the discussion of (3.27). Therefore, the total quantity produced under the UE regime is higher.

Chapter 4

INFORMATION DIFFUSION AND MISAPPROPRIATION OF TRADE SECRETS: AN EMPIRICAL INVESTIGATION

This chapter undertakes an empirical investigation to analyse the importance of trade secrets to companies using a sample of firms in European countries, "Survey on trade secrets and confidential business information in the internal market", prepared by Baker & McKenzie (BKM) (2013) for the European Commission to understand the trade secret information sharing and misappropriation incidences. A relationship between importance of trade secrets for the firms, information sharing and misappropriation behavior is established. We find that firms that share trade secrets information with third parties, are more likely to face acts/attempts of misappropriation of their trade secrets. We also find that firms are more likely to find secrecy important for their inventive knowledge, technical information and business information if they make high usage of patents, which points towards possible synergy between patents and secrecy. This is in line with recent research on the complementary nature of patents and trade secrecy.

4.1 Introduction

This chapter aims to analyse the possible relationship between information sharing and chances of misappropriation of trade secrets. There is little empirical work on trade secrets as compared to other forms of intellectual property. In the existing literature, trade secrets have mostly been studied with reference to patents. In this chapter, however, we look at the BKM survey data, focused mainly on trade secrets. We look at the possible relationship between the importance of trade secrets for the firms and their trade secrets information sharing behaviour with other parties in the industry. A relationship between trade secrets information sharing and misappropriation of trade secrets is established later in this chapter.

It is well documented that secrecy[1] is probably the oldest form of protection of innovative knowledge (Jorda 2008). Trade secrets management is a tough task, which involves not only keeping the secret knowledge safe within the organisation but also safe transfers and sharing of the secret knowledge with external parties. Information sharing is very important for technological and business needs of the firms in this world of cutting edge technological advancements. It has long been argued that corporates are not capable of 'going alone' in terms of technological advancements, especially in the markets where technologies are inherently interdependent (Quintas et. al., 1997). Firms regularly need to acquire external information in order to continuously innovate effectively. In transferring and receiving knowledge across the organisational boundaries, the firms need to balance two objectives; firstly they need to be open to receive the information from the networks and external sources, and secondly they need to protect their own intellectual capital from misappropriation, and maintain secrecy of its trade secrets portfolio. Quintas et. al. (1997), call the

[1] We use the words trade secrets and secrecy interchangeably in this paper.

risk associated with information sharing as a "boundary paradox"– alliance partners seeking knowledge and capabilities from external sources, while simultaneously facing the risk of exposing their own vital internal knowledge. Another problem with information sharing is known as Arrow's information paradox, which refers to the situation where the sellers do not disclose information to buyers if there is no legal protection, and therefore buyers are unable to value that information (Arrow, 1962). Thus, the legal setup determines the ease with which firms can do the knowledge transfer without facing misappropriation.

Corporations, especially in high-tech industries, are entering into an increasing number of alliances for various compelling reasons (Norman, 2001). Firms may gain many competitive advantages by having alliances with other firms in their industry, for example, lower costs, shared risks and speedier entry into the market. Firms may also gain access to external management and marketing technology. However, a potential partner may also be hoping to gain access to a firm's trade secrets knowledge and capabilities. Norman (2001) presents an example which helps us to understand the risk associated with vital information sharing with external parties. Apple engaged Microsoft to develop several tools for the Mac, such as spreadsheet, database, and graphical applications from 1982 to 1984. During this cooperation period, Microsoft acquired critical knowledge about Graphical User Interface (GUI) products of Apple, which probably helped Microsoft to develop the Windows operating system. Apple had brought a suit against Microsoft after realising this loss of critical knowledge, however it was unsuccessful.

This example points toward a distinction of the knowledge desired to be shared and the knowledge that is probably appropriated unlawfully. Thus, there seems to be a need for legal provisions to protect trade secrets information from misappropriation,

and at the same time, for smoother sharing of the information that is desired to be shared. The essence of the argument is that firms may not want to share all of their trade secrets knowledge, but just a part of it. In that case, the law should protect the interests of the parties who want to share some information, without the loss of other information.

On the policy frontier, the European Commission (2013) has enacted a proposal for a trade secrets Law Directive (IP/13/1176) on the protection of undisclosed know-how and business information (trade secrets) against unlawful acquisition, use and disclosure. It clearly shows that policymakers in the European Union (EU) are concerned about unlawful acquisition, use and disclosure of the secret information. The Uniform Trade Secrets Act (UTSA), ratified by most of the states, protects secret information in the United States (US). It has provisions to protect trade secrets of the firms against improper means of appropriation by other parties. It may be noted that there is no uniform law dealing with secrecy across the EU. However the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement provides for protection of trade secrets at a global level.

The purpose of this chapter is to investigate a possible relationship between sharing of trade secrets among firms and the chances of misappropriation of the secrets of the involved parties. We investigate this relationship with the help of the BMK survey, used for the report on trade secrets for the European Commission (2013). In particular we look at correlations between trade secrets information sharing and the incidences of misappropriation of secrets of the firms surveyed. We also look at the synergies between usage of patents and the importance of secrecy for the firms surveyed. In the next sections we present the relevant literature to motivate the discussion, the data and survey technique used in the sample, econometric methodology used, and

the econometric exercise respectively.

4.2 Related Literature

Traditionally economics literature on intellectual property management has focused on patents. Trade secrets law was termed as a neglected orphan in economic analysis (Friedman et al, 1991). It was documented that despite its importance for business entities, trade secrets has not caught attention of economics scholar. However, many researchers have worked in this area over the last two decades.

One of the most important papers where trade secrets and patents are compared is Anton and Yao (2004). Their findings suggest that firms use secrecy to protect their big innovations and they patent only small innovations. Refer to section 1.1.2 from Chapter 1 to have a relook at the patents-secrecy mix theoretical literature.

Other than these theoretical advancements, several empirical studies have looked at firms' preferred choice of protection of their intellectual property portfolio. In general, the results clearly point towards a high importance of trade secrets and other non-patent protection mechanisms when compared to patents. Some of the empirical papers are presented below.

A recent study on the usage of patenting by the United Kingdom (UK) firms brings out interesting results. It is found that only 1.6% of all registered firms in the UK engage in patenting (Hall et al. 2013). Furthermore, only 4% of the firms that report engaging in R&D have applied for a patent in the UK or the European patent office during 1998-2006. They report that even for hi-tech manufacturing sectors, hardly 10% of the firms engage in patenting behaviour. They argue that this suggests that firms do not patent all their patentable inventions automatically. Further, some firms do not patent at all because of the perception of not having any additional benefit by

patenting, whereas some firms do not patent because of unpatentable inventions.

This highlights the importance of non-patent and unregistered protection mechanisms. In this section we present the findings of other researchers regarding the preferences of R&D firms among different appropriation mechanisms[2]. There have been several studies based on European countries. They are summarised below.

Focusing on Swiss firms, Harabi (1995) found that patents were generally the least effective method of appropriation for both process as well as product innovations. His results are based on a survey of 358 R&D executives of selected firms. He argues that possibilities of inventing around and the perception that too much information is disclosed in patent documents explain why patents are not considered effective means of appropriation. He points out that except in a few industries[3], patents are not used to appropriate technological innovations.

Arundel (2001) studies the relative effectiveness of patents and secrecy as an appropriation tool in Europe. He analyses data from the 1993 European Community Innovation Survey[4] (CIS) for R&D performing firms to observe the relative impor-

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[2]Appropriation mechanisms include various options available to the firms to protect their innovative knowledge. It may include secrecy, patenting, copyrights etc.

[3]In chemicals, including drugs, and sometimes the machinery and electrotechnics industries are found to use patents as appropriability mechanisms.

[4]The Community Innovation Survey (CIS) is a survey of innovation activity in enterprises encompassing EU member states, EU candidate countries, Norway and Iceland. CIS provides information on the characteristics of innovation activity at the enterprise level. Among various other objectives, it serves to describe the innovation process, measure its economic influence, evaluate its effects and assess its mechanisms. The survey concepts are in line with the recommendations of the Oslo Manual (2d edition 1997). As part of the 1993 CIS, the questionnaire asked respondents to appraise the effectiveness of various protection methods for both product and process innovations of patents, registration of design, complexity of process design, lead time advantage over competitors, and secrecy. However questions related to preferred protection mechanisms were eliminated in later CIS.

CIS information can be reached at http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/cis

tance of secrecy vs. patents[5]. His results show that in all size classes of firms, secrecy is considered more important than patents. The authour studies two kinds of innovations, namely product innovation and process innovation. He performed an ordered logit analysis and discovered that as the size of the firm increases, the probability that firms rate secrecy as more valuable than patents diminishes for product innovation, while there exists no significant association of such kind in the case of process innovation. Further the firms' R&D intensity has no significant effect on the relative value of secrecy and patents. Overall, it is found that secrecy is more important for all size classes of firms for product innovation as well as for process innovations.

Hussinger (2005) studies the importance of patents vs. secrecy from a different angle. Instead of looking at the firms' opinion about the relative importance of secrecy and patents, she uses the protected invention's success (in terms of sales associated with that invention) to assess the relative importance of patents and secrecy. She uses the data of 389 German manufacturing firms from 1992 to 2000, and finds that patents are more important than secrecy for product innovating firms. She finds a positive correlation between patenting and proceeds from new products whereas no such significant relation exists for secrecy. Hussinger argues that firms might be using patents more for the protection of product innovations, which may be subject to reengineering, whereas secrecy may be more useful to protect process innovations. She suggests that the frequent use of secrecy may be interpreted as a useful tool to protect the innovation in the early stages.

Gonzalez-Alvarez and Nieto-Antolin (2007) investigate the choice of protection mechanisms using a sample of 258 Spanish manufacturing companies. Protection mechanisms such as patents, industrial secrets, cost and time for imitation, and con-

[5]The survey was conducted in Norway together with six other EU countries: Germany, Luxembourg, the Netherlands, Belgium, Denmark, and Ireland.

tinuous innovation are considered. Knowledge is classified in two types: explicit and tacit. Explicit knowledge is knowledge that is codified and can be reduced to specific information such as formulas, diagrams, numbers, or words. Tacit knowledge cannot be easily codified and resides essentially in the minds of individuals and patenting this knowledge requires precision and the procedures can be extremely costly for companies. Their empirical analysis substantiate the stand that companies that mostly use explicit knowledge are likely to choose patents as a protection mechanism, whereas companies that hinge on tacit knowledge are likely to use trade secret protection more intensively.

Moser (2007) presents an analysis of historic inventions and how inventors use alternative appropriation methods. She examines a novel data set of around 7,219 American and British innovations, with and without patents, from four world's fairs between 1851 and 1915. It is argued that the possibility of keeping a secret may explain the patenting decisions of firms and that inventors are likely to avoid patents for innovations that can be kept secret. Scientific breakthroughs, which are likely to be reverse-engineered by competitors, increase the propensity to patent an innovation. Based on the exhibition data, the author derives insights as to when innovations are likely to be patented, as well as the situations when scientific advances, which might help reverse-engineering, weaken secrecy and encourage patenting. One of the findings is that firms patented just a small proportion of innovations. For instance in 1851, just 11% of British innovations were patented while the proportion was 15% for American firms. This signifies the importance of non-patent mechanisms of protection. It is also found that the patenting rates significantly differ among different industries. Urban inventors are found to rely on patents relatively more.

Pajak (2010) studies whether large innovative firms rely on big secrets. Using the

French part of CIS 4 dataset he analyses what kind of innovation is protected by which kind of protection mechanism. He uses a bivariate probit model and finds that in the intermediate goods industry, small innovations are patented while secrecy is used to protect large ones. His findings support the view that firms regard patents not more useful than secrecy, and the higher use of secrecy limits diffusion of knowledge in society.

There are some other studies focusing on the US where they show that manufacturing firms rate secrecy more than patents for both product innovation as well as process innovation. However there is one exception: In Japan firms give more rating to patents for product innovation whereas secrecy is preferred in the case of process innovation (Cohen et. al., 2000).

Levin et. al. (1987) present the empirical analysis based on a survey of US high level R&D executives. Analysis of the survey data reveals that firms in many industries regard appropriability mechanisms other than patents more effective in appropriating returns from innovation. For instance, lead time, speed down the learning curve, and sales and service efforts are all found to be more effective than patents with respect to both process and product innovations. Secrecy is regarded more effective than patents for process innovations, but slightly less effective than patents for product innovations.

Cohen et. al. (2000) also analyse the effectiveness of appropriation mechanisms. Based on a survey questionnaire directed to 1478 R&D labs in the U.S. manufacturing sector in 1994, they show that firms typically protect their invention with a range of mechanisms, including patents, secrecy, lead time advantages and the use of complementary marketing and manufacturing capabilities. But out of these alternative mechanisms, the majority of manufacturing industries emphasize secrecy more than

patents. They also argue that with a comparison to Levin et. al. (1987), the use of secrecy has increased over time for most industries for product innovations.

Almeling et. al. (2010) presented the first ever statistical analysis on trade secrets litigation in federal courts in the US. They report findings from 394 cases brought under trade secrets law, in which courts issued a written opinion between 1950 and 2008. The focus of their analysis was on questions such as: what type of secret was lost, who was the alleged misappropriator and what law did the courts apply. Some of their findings can be summarised as: i) Trade secrets litigation cases have grown exponentially (trade secret cases doubled in the seven years from 1988 to 1995, and doubled again in the nine years from 1995 to 2004) ; ii) In over 85% of the cases, the owner of the secret knew the alleged misappropriator (either an employee or a business partner), iii) The chances of trade secrets owners prevailing on a motion for preliminary relief were better when they sued their employees as compared to when they sued their business partners. This study provides the basic understanding of trade secrets litigation in the US; however, it remains a descriptive statistical analysis.

The purpose of the current chapter is to understand the possible relationship between the sharing of trade secrets of the firms and the possibility of misappropriation of its secrets, using the BMK sample of European firms. In the EU, the European Commission has taken the issue of misappropriation seriously and has brought a proposal for a uniform and strong protection across the EU. The European Commission wants to bring a strong law to protect the secrets of European firms against unlawful appropriation. This study may provide some policy advices in the process of modifying the law. If it is found that firms that share their secret information with external parties, are more likely to face misappropriation of their secret knowledge, it may indicate possible problems with existing law governing technology transfers. With this

information, the law makers would be in a better position to hit the target of protecting trade secrets of the firms in the EU. Therefore, our study has a direct policy relevance. It may be noted here that after Arundel (2001), no study has been carried out on trade secrets based on multiple countries in the EU. This chapter throws fresh light on the importance of trade secrets knowledge of the firms, the synergy between the usage of patents and secrecy, and the information sharing behaviour of the firms in Europe.

4.3 Data and Survey Methodology

This chapter uses the data of the BMK survey for the EU report on trade secrets. The methodology of data collection is based on the guidelines of the OSLO manual 3rd edition (2005) which is generally used to collect and interpret data on innovation, developed by the Organisation for Economic Cooperation and Development (OECD) and EUROSTAT. This manual is used as a reference for empirical research on innovation. It may be noted that the CIS, the biggest survey on innovation across Europe, follows this manual for data collection. Trade Secrets have a much broader reach than innovation because its scope goes beyond innovation[6]. The target population of the survey was a subset of the EU business enterprise sectors which include both goods producing and services producing industries (except public enterprises).

According to the OSLO manual, the enterprise is generally the most appropriate statistical unit for the innovation data collection (Oslo manual, Chapter 4). The enterprise is defined by the OSLO manual, Chapter 4, as "the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision making, especially for the allocation of

[6]For instance, customers lists can be trade secrets, even when there is no innovation involved.

its current resources. It may carry out one or more activities at one or more locations and it may be a combination of legal units, one legal unit or part of a legal unit." The multinational corporations in the survey are considered as local independent branches.

Economic activities are classified in accordance to the NACE [7] rev. 2. The selection of the economic sectors follows the CIS 2008 closely. However, not all the sectors make intensive use of trade secrets[8], thus, the survey was designed to include the sectors with due consideration to the usage of trade secrets.

Only one person was in charge for responding to the questions in the survey, the chief executive officer (CEO) or the managing director for small and medium enterprises and the General Counsel for the large enterprises. The respondent might have been the chief intellectual property counsel or the head of R&D department as well.

The survey frame included the following countries; Austria, Belgium, Czech Republic, France, Germany, Hungary, Italy, The Netherlands, Poland, Spain, Sweden, Switzerland and the United Kingdom. The survey was carried out during November 14, 2012 to December 4, 2012, using web interviews and telephone interviews. The sample was stratified so as to include at least two respondents for each activity and each country: one small-medium and one large enterprise[9].

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[7] NACE (Nomenclature des Activités Économiques dans la Communauté Européenne) represents a European industry standard classification system, which is similar to other standards like Standard Industry Classification (SIC) and North American Industry Classification System (NAICS) for classifying business activities. This kind of classification allows us to compare firms' economic activities on a statistics basis.

[8] Some sectors do not make intensive use of trade secrets (the French CIS 2004 and 2006). For instance, 'Mining and Quarryin', 'Wholesale trade', 'Transportation and storage', and 'Information sevices activites' report a low usage of trade secrets. For more information, refer to the report, "Survey on trade Secrets and confidential business information in the Internal Market (2013)".

[9] The EU report uses a total sample of 537 respondents. Among these 537 observations, there were 51 observations of the companies which themselves chose to participate in the survey. In this paper, we remove those self selected responses, therefore our sample size is 486.

Business Sector	**Share (%)**
Manufacturing: Textiles	6.79
Manufacturing: Chemicals and chemical	4.53
Manufacturing: Basic pharmaceutical	3.91
Manufacturing: Computer, electronic, optical	5.14
Manufacturing: Machinery and equipment	7.61
Manufacturing: Motor vehicles	3.50
Electricity, gas, steam and air conditioning supply	4.12
Water supply; sewerage, waste management and remediation activities	0.82
Publishing activities	5.76
Telecommunications	2.26
Fast moving consumer goods	6.38
Computer programming, consultancy and related activities	6.58
Financial and insurance activities	6.79
Scientific research and development	7.41
Legal and accounting activities	5.56
Biotech	0.00
Wholesale trade	4.53
Retail trade	0.21
Other	18.11

Table 4.1: Business Sectors Sampled and their relative shares in the sample

The survey process was as follows: the demographics of the sample were extracted using systematic sampling with random numbers. The survey technique used was structured questionnaire. The companies were contacted by phone and were informed about the European statistical survey and that they had been chosen completely random. They were asked to fill in the online survey then, with the credentials provided to them. The questions were translated to the local languages for the specific country in question. To monitor the data collection, three E-mail reminders and two phone call reminders were used. Table 4.1 and Table 4.2 present the share of different industry sectors surveyed and share of countries surveyed.

We can gain many important insights related to the protection of trade secrets

Countries	**Share (%)**
Austria	7.82
Belgium	7.61
Czech Republic	7.82
Denmark	0.21
Finland	0.21
France	5.76
Germany	6.38
Hungary	8.85
Italy	12.14
The Netherlands	6.79
Poland	6.79
Slovenia	0.21
Spain	8.02
Sweden	8.02
Switzerland	7.00
United Kingdom	5.56
Ireland	0.21
USA	0.62

Table 4.2: Share of Firms in the sample by country

among the European firms with this survey because of its richness. To understand the data better, we present several summary characteristics of the variables used in this study. We also analyse some other closely related issues. For instance, we look at the synergy between the importance of trade secrets and usage of patents by the firms. It has been argued that firms do not necessarily choose either secrecy or patents, but might want to choose both of them (Ottoz and Cugno, 2008). We look at the relationship between the importance of secrecy and importance of patents of the surveyed firms.

Responses of firms to the question regarding the importance of trade secrets with respect to technical information, business information and competitiveness and innovative growth are presented below (Refer to Figure 4.1, Figure 4.2 and Figure 4.3). The figures clearly show a high importance of trade secrets in general for most categories. In particular, firms give a high value to secrecy for protection of product technology, process know-how and R&D data in the technical information field, and financial information and business planning, commercial bids and customer list in the business information field. For innovative growth and competitiveness of firms, around 33% of the firms value secrecy highly, and 42% of the firms value secrecy to be of medium importance.

Now we look at the issues of usage of patents by the firms, the trade secrets sharing behaviour of firms and the misappropriation of secret information during the last 10 years, both inside the EU and outside the EU. Figure 4.4 represents the extent of usage of patents of the firms surveyed. It comes from one of the questions in the survey which asked ,"To what extent does your company rely on other intellectual

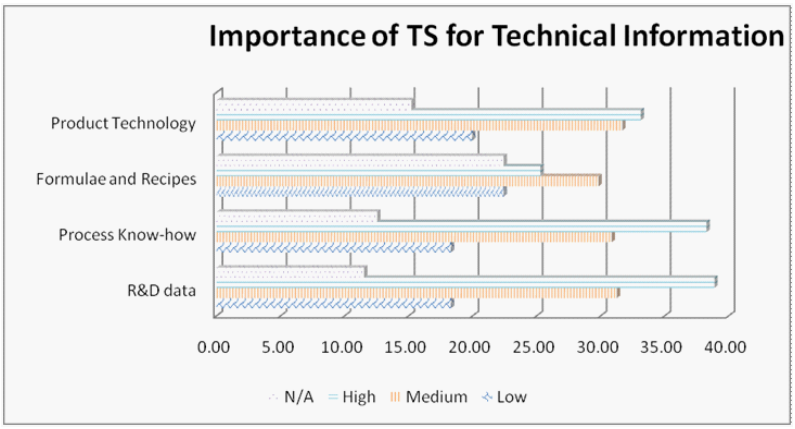

Figure 4.1: Importance of TS for Technical Information

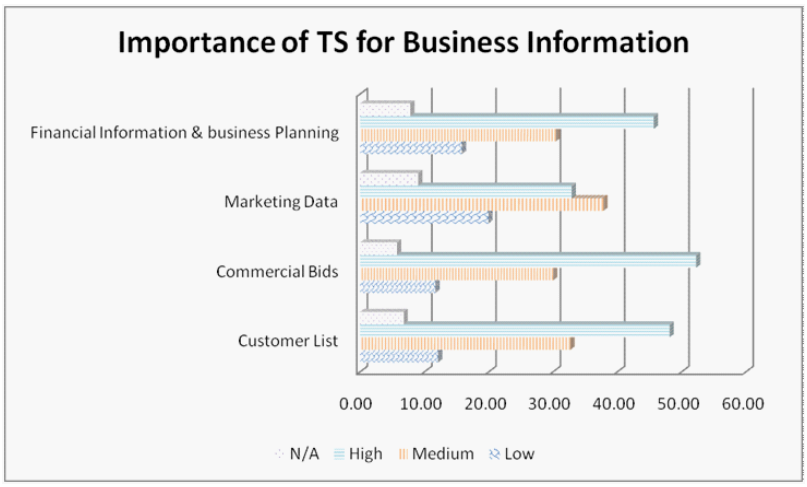

Figure 4.2: Importance of TS for Business Information

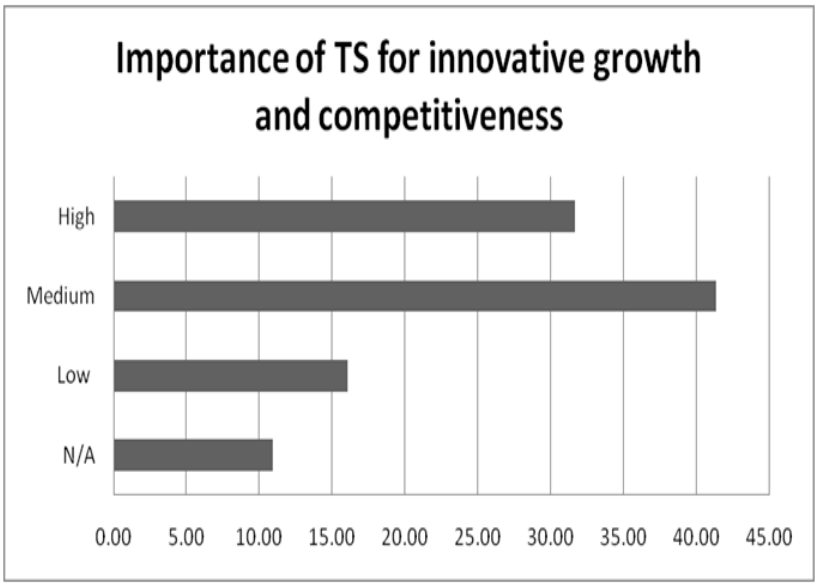

Figure 4.3: Importance of TS for innovativeness and competitiveness

property rights[10]?" It is worth noting that most of the firms in the sample put a very low emphasis on patents. Approximately 25% of the firms report having a high usage of patents whereas nearly 20% firms report medium level usage of patents. However, most firms put a low reliance on patents (nearly 28%). This is in line with the findings of all other studies discussed in the literature in the Related Literature section.

The question on the use of other intellectual property rights can be understood better with the responses of the surveyed firms regarding the reasons to protect their knowledge with secrecy as compared to other intellectual property rights. Most of the firms report unwillingness to disclose information as the main reason to protect their knowledge with secrecy. Referring to Figure 4.5 , we note that the second most important reason is lack of eligibility of other protection measures whereas the third

[10]Other intellectual property rights included patents, copyrights, trademarks and designs in the BKM survey questionnaire.

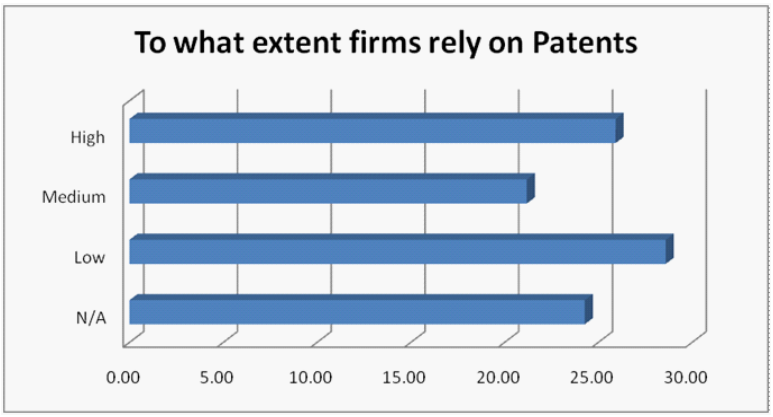

Figure 4.4: Reliance of firms on patents

one is uncertainty of granting of other intellectual property rights[11]. Costs to manage other intellectual property rights is also a consideration for the firms. Finally, some firms think that the protection with other measures is not adequate when compared to trade secrecy.

Figure 4.6 shows trade secrets sharing of the firms with third parties through contracts or other arrangements, for e.g. know-how transfer, services know-how and transfer or licensing of unpatented technology. We note that nearly 15% of the firms share information regularly with other firms. Around 42% of the firms share information occasionally whereas around 43% firms report no information sharing. In the empirical section we look at the relationship of information sharing behaviour with various variables such as the importance of secrecy, size of the firm, etc.

The question of information sharing was further supported by a question on the reasons for not sharing information. Figure 4.7 represents the responses by the firms

[11]Please note that multiple answers were allowed, so we see that sum of all the options does not sum upto 100 percent. For some other questions later, the same explanation applies.

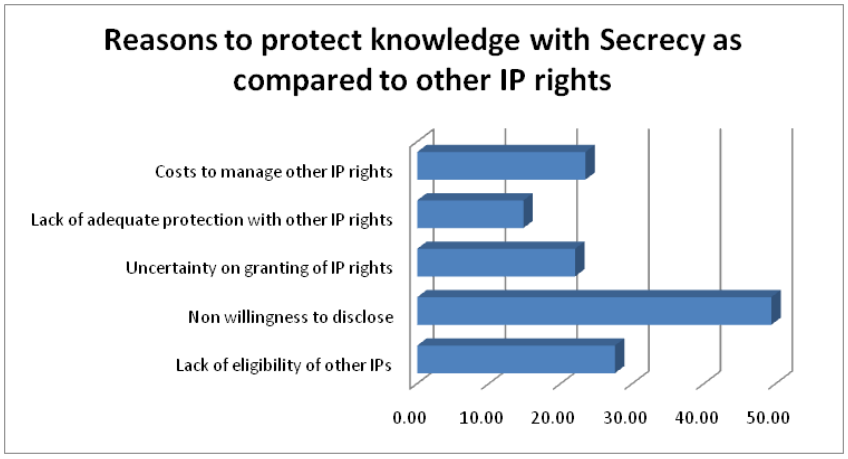

Figure 4.5: Reasons to use Secrecy as compared to other IP rights

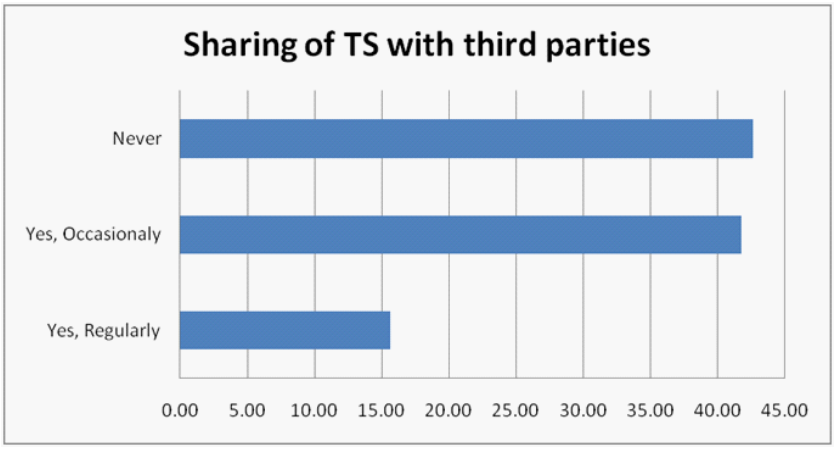

Figure 4.6: Information Sharing with third parties

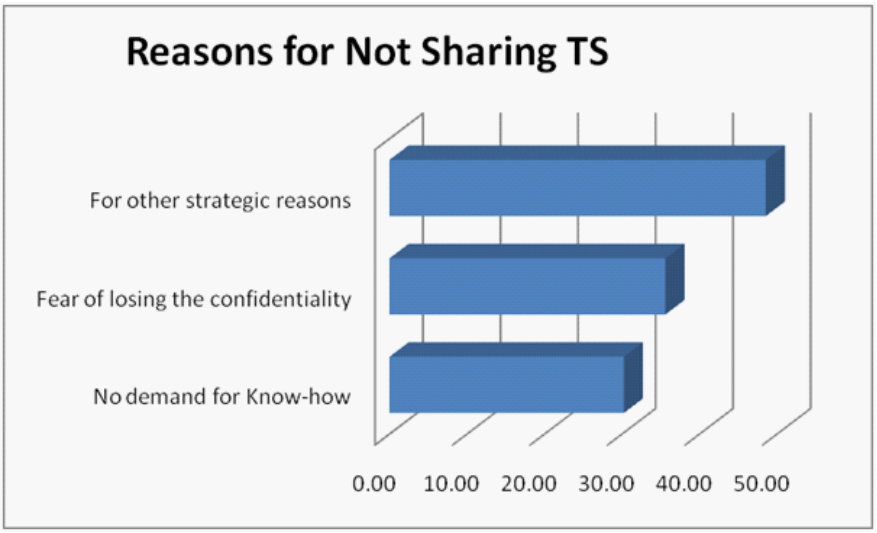

Figure 4.7: Reasons for not sharing TS with other parties

for not sharing trade secrets information. Most of the firms consider "other strategic reasons" to be the prime reason for not sharing, followed by fear of losing the secret in the process of sharing information. Approximately 28% of the firms report having no market for their know-how.

The firms were also asked about the ways in which firms in their business sector obtain information about products, services and strategies of other market players. It was an important question in the survey, as one of the options to this was espionage. It may reveal some of the misappropriated flow of information among the firms indirectly. Figure 4.8 shows the responses. Clients are the most important source to obtain information, closely followed by suppliers of equipment. Firms also obtain information through reverse engineering and employee mobility. It may be stressed here that there may be restraints on employee mobility in some countries such as "covenants not to compete" agreements. It is interesting to find that firms report using espionage to

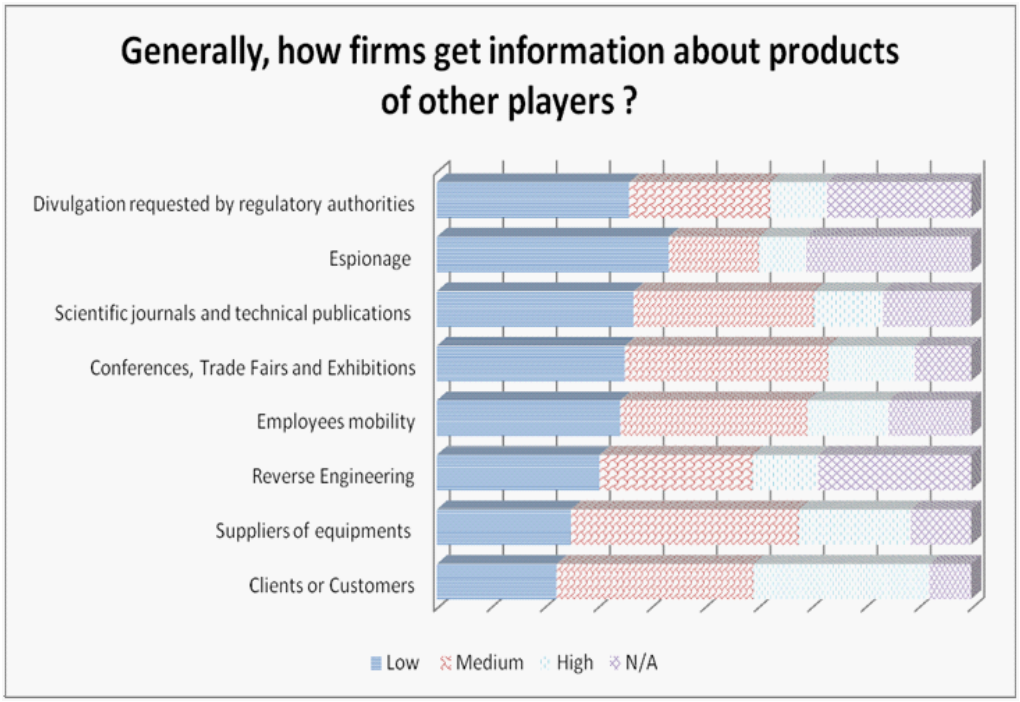

Figure 4.8: In general, how do firms get information about products of other players in your industry?

acquire knowledge, which point towards illegal transfers of knowledge in the market more generally.

We also look at who may generally be responsible for acts of misappropriation of firms' secrets. In other words, who poses a risk of leakage of secret knowledge for the firms surveyed? Figure 4.9 presents the risk of leakage of trade secrets posed by various players. It can be seen that competitors and former employees pose a high risk to the firms, followed closely by current employees and clients of the firms. Overall, almost all firms report having medium to high risk from employees, both former and current, competitors, clients, internal and external consultants.

Figure 4.10 reveals the attempts/acts of misappropriation of secrets during last 10

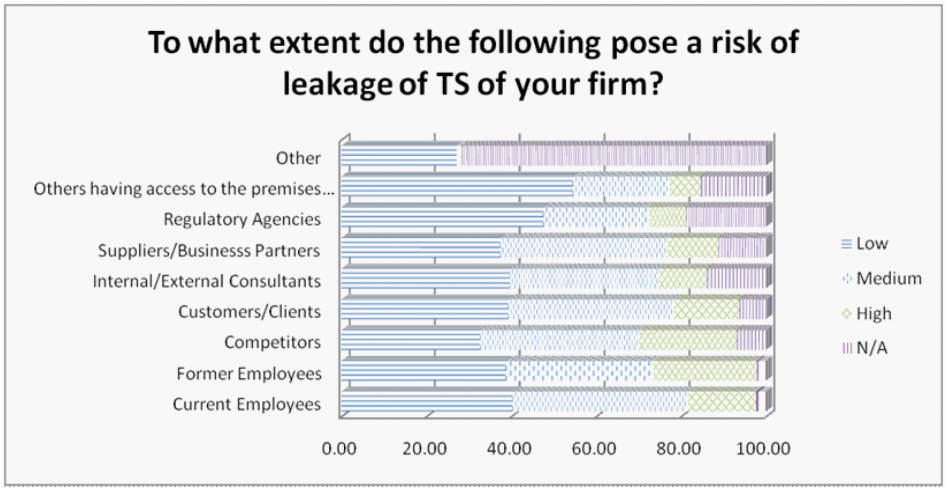

Figure 4.9: To what extent do the following pose a risk of leakage of TS to your firm?

years, both inside the EU and outside the EU region. It is observed that around 20% of the firms surveyed had faced attempts/acts of misappropriation, out of which around 4% of the firms have experienced it more than 5 times. Further, firms have faced a higher incidence of misappropriation behaviour inside the EU region as compared to that of outside the EU region. It may be noted here that around 38% of the firms surveyed report to be multinational entities.

The attempts/acts of misappropriation of secrets were carried out mainly by competitors, former employees and customers for the firms surveyed. Figure 4.11 presents the parties that were involved in acts or attempts of misappropriation of secrets of the firms. Former employees are the second most reported cause of misappropriation behavior. At this point, we may note that misappropriation behaviour by former employees might be partly deterred by the imposition of "covenants not to compete" clauses in employee contracts.

Finally, we look at the consequences of attempts/acts of misappropriation in terms

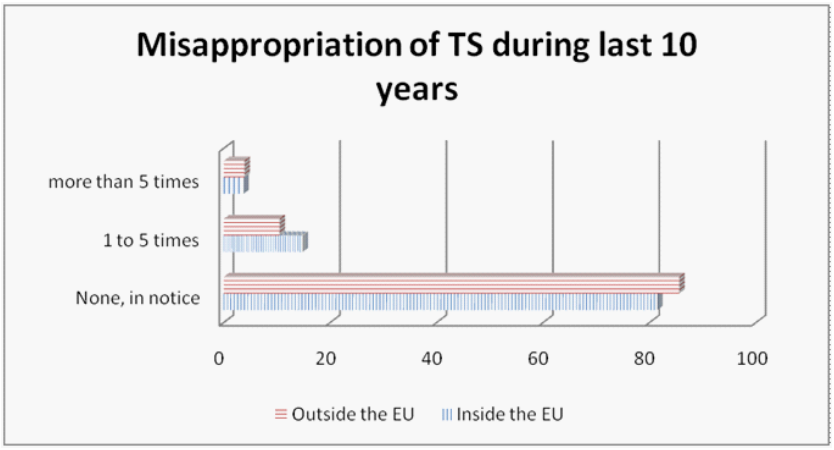

Figure 4.10: Misaapropriation of TS

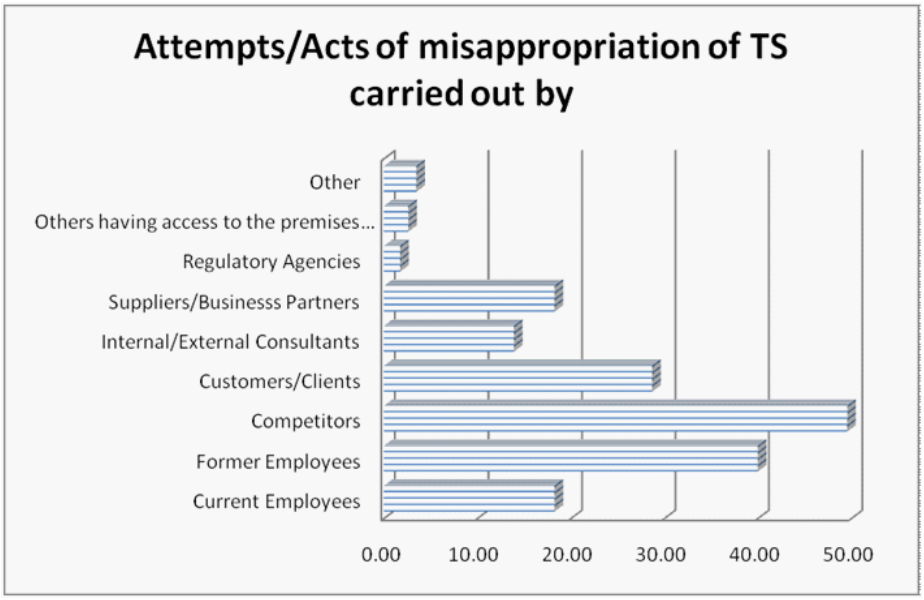

Figure 4.11: Attempts/Acts of misappropriation carried out by different players

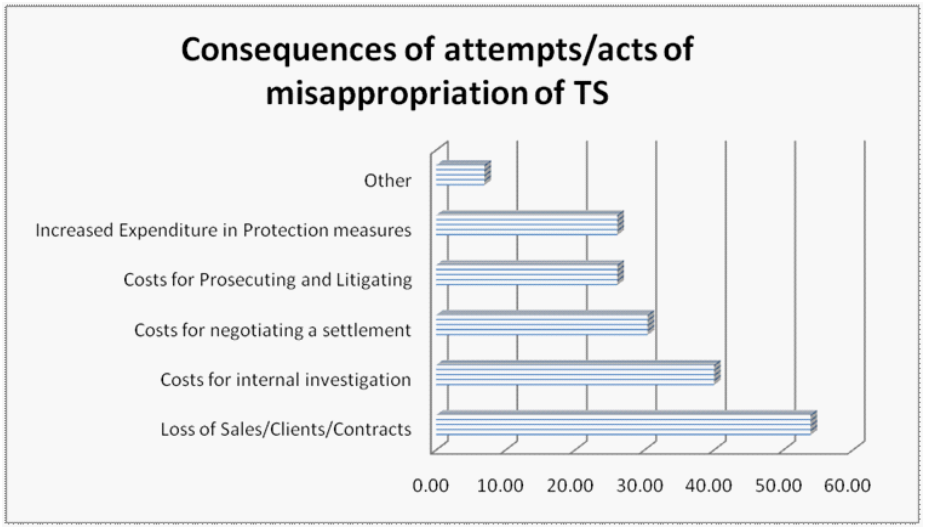

Figure 4.12: Consequences of attempts/acts of misappropriation

of its effects on sales of the final products, changes in internal costs of protection, litigation and negotiation costs.

Figure 4.12 presents the consequences of attempts/acts of misappropriation. We find that loss of sales, clients and contracts is the most important consequence of misappropriation of trade secrets, as reported by the firms surveyed. Costs for internal investigation, costs for negotiations and settlement and costs of litigating have also been reported to be consequences of misappropriation of trade secrets. Finally, increased expenditure on protection measures is also reported to be a consequence of misappropriation behaviour.

The summary statistics of the variables used in this study are presented in Table 4.3.

We looked at various variables of interest in this section, which we further analyse with econometric analysis later. We found that most firms consider trade secrets to be critical for their technical information, business information and innovative

Variables	Observations	Mean	Std. Dev.	Min	Max
Multinational dummy	486	0.381	0.486	0	1
Short Lifecycle dummy	486	0.364	0.482	0	1
Manufacturing dummy	486	0.315	0.465	0	1
Small firms dummy	486	0.416	0.493	0	1
Medium firms dummy	486	0.210	0.408	0	1
Medium Patent Usage dummy	368	0.280	0.450	0	1
High Patent Usage dummy	368	0.342	0.475	0	1
Medium importance of Secrecy for innovativeness and competitive growth	433	0.464	0.499	0	1
High importance of secrecy for innovativeness and competitive growth	433	0.356	0.479	0	1
Medium importance of Secrecy of technical information	486	0.247	0.432	0	1
High importance of secrecy of technical information	486	0.638	0.481	0	1
Medium importance of Secrecy of business information	486	0.243	0.429	0	1
High importance of Secrecy of business information	486	0.689	0.463	0	1
Occasional information sharing dummy	486	0.418	0.494	0	1
Regular information sharing dummy	486	0.156	0.364	0	1

Table 4.3: Summary Statistics of the Variables Used in Empirical Analysis

knowledge. It was found that the prime reason for the firms to protect their knowledge with trade secrets as compared to other intellectual property rights was their non-willingness to disclose their knowledge, followed by lack of eligibility of other intellectual property rights and the costs to manage other intellectual property rights. We also found that firms regularly share their trade secrets with external parties, nearly 42% of them share their trade secrets occasionally, and nearly 16% of the firms do it regularly. Finally, we found that significant incidences of misappropriation of trade secrets were reported by the firms, both inside the EU and outside the EU.

In the next section, we look at some other related issues that were analysed in the BKM survey. The issues in the next section are not econometrically analysed in the present chapter, but give important insights on the issues closely related to the research questions of this chapter. For instance, we look at the risk of misappropriation of trade secrets during the last decade, the problems associated with no uniformity in the rules of protection of trade secrets across the EU. We also look at firms' inclination for a common protection regime for trade secrets in the EU and the perceived effects of a uniform legal structure dealing with trade secrets.

4.4 Other Related Issues Analysed in The Survey

In this section, we present several other related questions from the survey. The related questions which will be covered in this section are not analysed in empirical detail because they are not intrinsically related to the research question. However, these issues do illustrate the context in which the survey was conducted and provide a reflective foundation from which to consider associated issues for future research. The

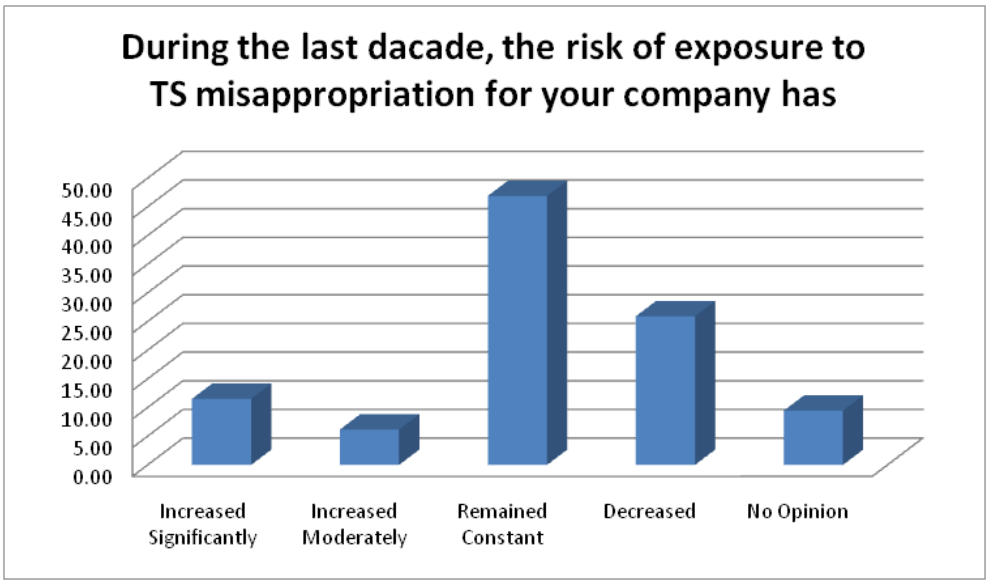

Figure 4.13: During the last decade, what is the change in the risk of exposure to TS misappropriation for the firms.

other issues from the survey relate to topics such as: the risk of misappropriation[12] during the last decade, the problems faced by the firms during legal proceedings in the EU, and the desirability of having a common framework of trade secrets protection in the EU[13].

One of the questions in the survey was whether the risk of misappropriation of trade secrets has increased, remained constant, or decreased during the last 10 years.

We note that nearly 10% of the firms report significantly increased risk of exposure to trade secrets misappropriation and 4% report a moderate increase in the risk, whereas nearly 45% of the firms report having no change. Nearly 24% report a

[12]Note that in our empirical analysis, we look at the actual incidence of misappropriation. In this section, however, we report the responses of the firms about the perceived risk of misappropriation of their trade secrets.

[13]The figures presented below are made from the refined survey data. Please read the "Data and Survey Methodology" section for a discussion of how the data was refined from the BKM survey.

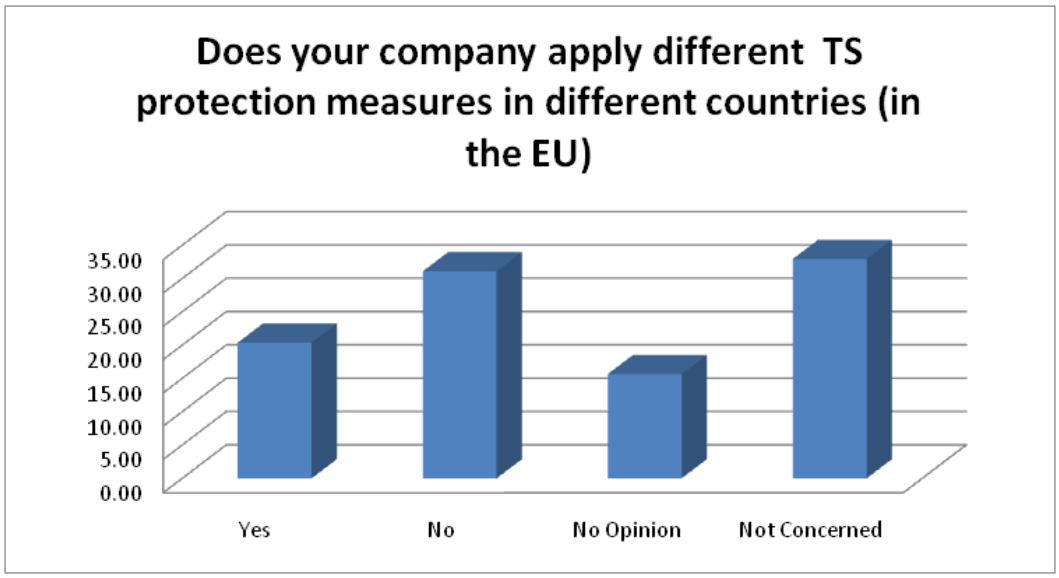

Figure 4.14: Whether companies apply different TS protection measures in different countries (in the EU)

reduced risk of exposure to trade secrets misappropriation. Thus, for most firms, the risk has either increased or has remained constant during the last decade. One of the main purposes of the survey was to understand the potential problems faced by companies in the EU in protecting their trade secrets in the member states. Since there is no uniform system dealing with secrecy in the EU, firms that operate in many member states may find it difficult to manage their trade secrets portfolio (possibly due to different rules and regulations in different member states). The firms were asked whether they applied different protection measures in different countries in the EU.

Figure 4.14 presents the responses of the firms to this question. Around 16% of the firms apply different trade secrets protection measures in different countries, around 31% of the firms do not apply different protection measures, nearly 10% of the

firms have no opinion and, finally, around 30% of the firms report having no concern with this question. Thus, firms do not seem to apply different protection measures in different member states. In fact, most of them are not even concerned with the issue.

Another important aspect is to look at what happens when firms go to courts in the cases of misappropriation of their trade secrets. The firms were asked whether they sought legal remedies before courts located in the EU if they faced misappropriation of their trade secrets during last 10 years. Around 10% of the firms, which faced misappropriation, reported seeking legal remedies in the EU courts always, whereas around 20% of them seek legal remedies in some cases only (Figure 4.15). Around 10% of the firms litigated outside the EU only. What is interesting to note is that most firms just did not use legal remedies in cases of misappropriation of their trade secrets.

Further, the firms were asked whether they were able to obtain specific remedies or not, if they sought legal remedies against misappropriation of trade secrets within the EU.

Figure 4.16 shows the responses of the firms regarding the remedies they could obtain in misappropriation cases. Nearly 35 % of the firms that sought remedies in the courts in the EU got criminal sanctions against the perpetrator, around 33% of them report award of damages, and nearly 30% could get court orders to search and secure evidence of misappropriation. Around 22% of the firms were able to obtain court orders stopping the unlawful use of the misappropriated secret, nearly 15% report of having none of the given remedies and nearly 15% could obtain monetary fines for the organisations involved in misappropriation. Nearly 13% of the firms got orders for the destruction of goods that were manufactured using the misappropriated trade secrets, around 13% publication of the court decisions in the press, and lastly, nearly

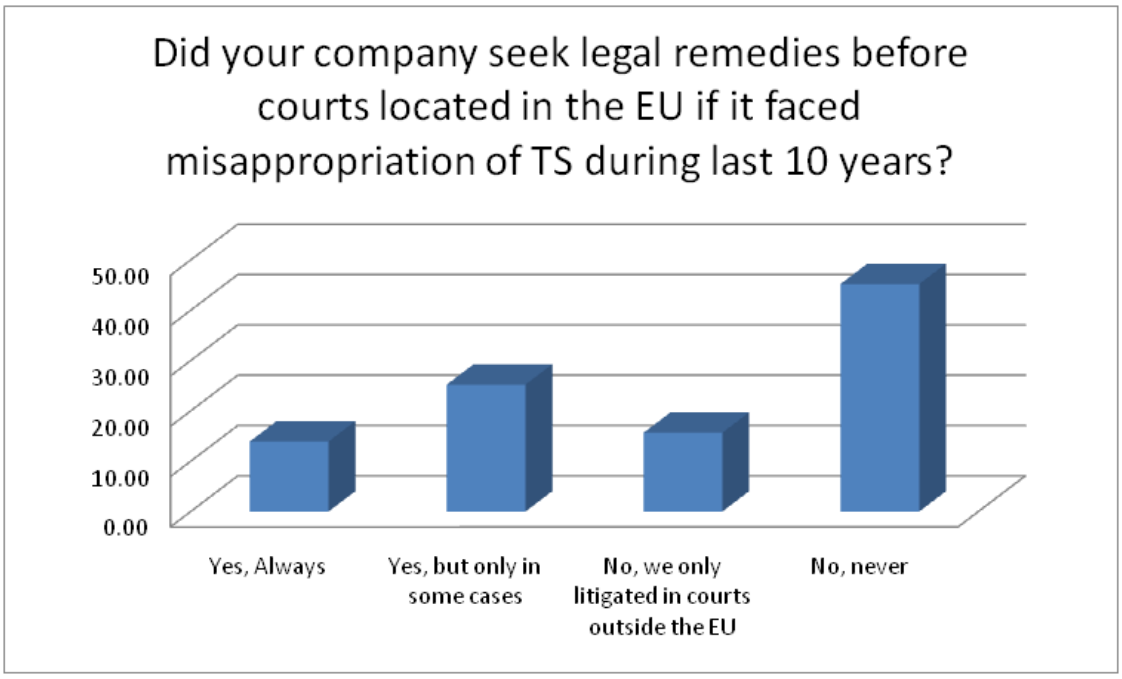

Figure 4.15: Did your company seek legal remedies before courts located in the EU if it faced misappropriation of TS during last 10 years?

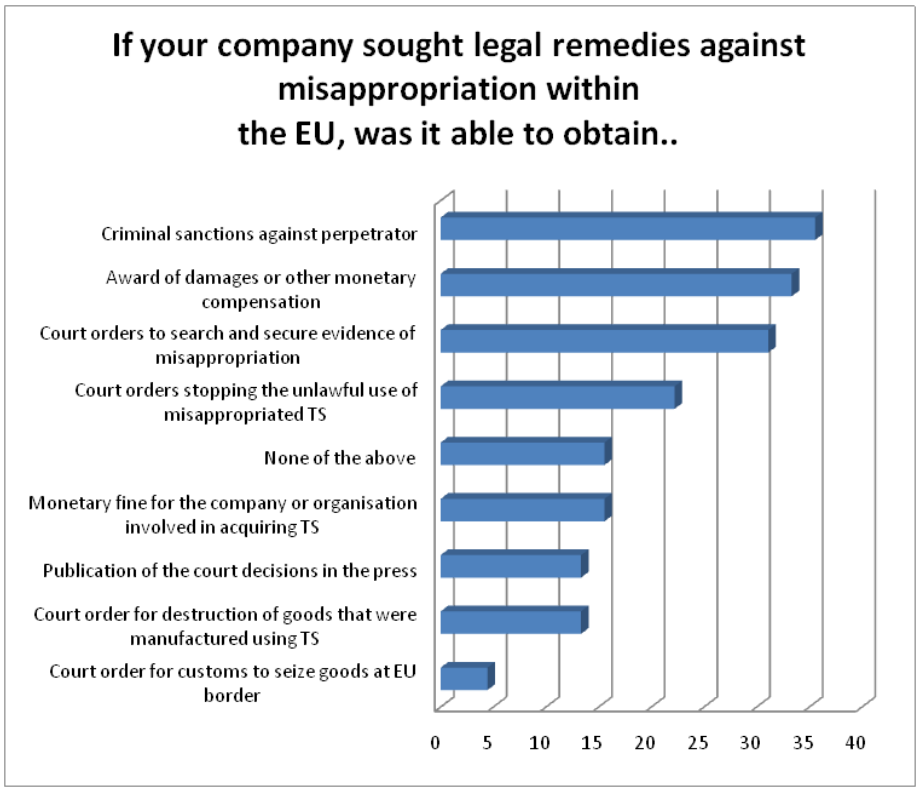

Figure 4.16: Whether the firms were able to obtain remedies if they sought legal remedies against misappropriation of TS in the EU.

Figure 4.17: In case of litigation within the EU, if a company obtains an order from a national court to stop the use of misappropriated TS in the territory of that Member State, does it try to enforce this order in other Member States?

4% could obtain court orders for customs to seize goods at the EU border.

In case of litigation within the EU, if a firm obtains an order from a national court to stop the use of misappropriated trade secrets in the territory of that member state, can the firms then enforce this order in other member states as well? This has implications for the firms that operate in multiple countries. Further, this is useful to understand the need of a uniform trade secrets protection system in the EU.

Figure 4.17 presents the responses of the firms regarding the enforcement of court

orders of one member state in the other member states. Most firms (around 28%) reported that they tried to enforce the court orders in other member states but were not successful in all member states in the EU. Nearly 21% of the firms reported using the same court orders in all member states and they were successful in applying the orders in all the member states. Around 15% of them preferred to start separate legal actions in different countries, according to the relevant legal system, nearly 13% did not try to enforce the same court orders in other countries because of the uncertainty of the results in other member states, and around 10% were not concerned because the case concerned only one member state. Finally, some firms (nearly 3%) thought it too costly to seek legal protection in other member states, so they did not try to enforce the court orders across multiple member states.

The firms were also asked about the reasons for not seeking remedies against misappropriation in the EU. Figure 4.18 presents their responses.

We note that most firms (nearly 44%) find it difficult to collect evidences in misappropriation cases, around 33% consider litigation costs to be the reason behind not seeking legal remedies in the EU, almost 30% don't indulge in the legal proceedings because they think that initiating legal action would bring the case to public attention, and around 28% report inability to quantify damages as the reason. Some firms also find the expected duration of the litigation (28%), low value of the trade secret in question or of damages caused (28%), lack of effective legal remedies (22%), preference for out-of-court settlement (22%), low probability of collecting awarded damages (18%) and inability to identify the offender (16%) to be deterrents for the firms seeking legal remedies in the EU. Finally, lack of trust in the judicial system of the relevant member state (13%) and the fear of losing the trade secret in court proceedings are the reported reasons. These responses highlight the perceived problems

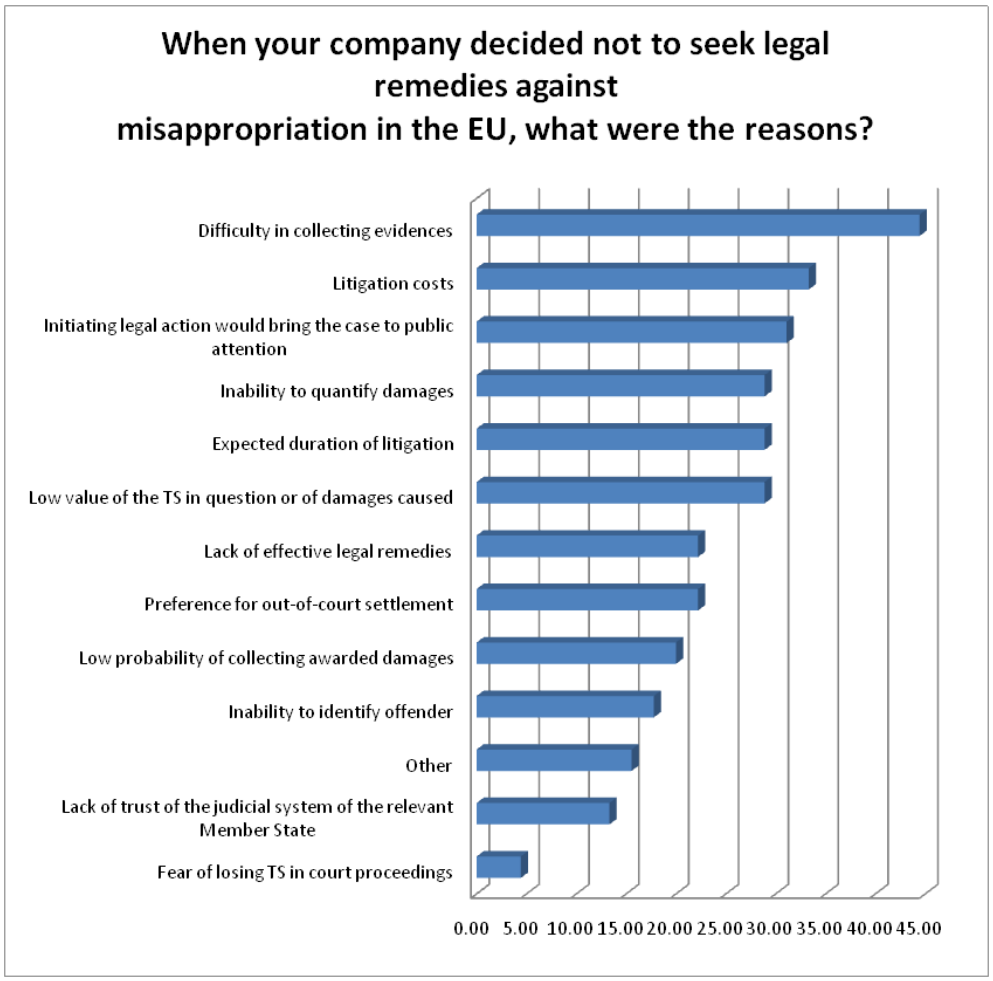

Figure 4.18: The reasons behind the firms not seeking legal remedies in the EU against misappropriation

that trade secrets owners face while deciding about carrying out legal proceedings in the EU. It points out the possible shortcomings of the existing legal system in dealing with trade secrets misappropriation.

Lastly we look at a set of questions revolving around the desirability of having a uniform legal system of protection of trade secrets across the EU. The survey included a question about the desirability of a new law ensuring that the national rules providing relief against misappropriation of trade secrets also provide effective and equivalent protection across the EU. Almost 65% of the firms believe that the EU should propose an EU legislation that ensures the uniformity of protection against the misappropriation of trade secrets across the EU (30% of these firms do it provided that it does not lower the level of protection of trade secrets in countries where their company is seated or operates). Figure 4.19 presents the responses of the firms for the desirability of this proposal. Nearly 16% of the firms do not want the new legislation whereas around 14% of the firms do not have any opinion.

The firms were asked directly whether they would benefit from an EU legislation establishing common rules for protection of trade secrets across all members. Figure 4.20 presents their responses on this issue.

Most firms want more clarity on what are the trade secrets to be protected by the law (50%), and prohibition of acts of misappropriation of trade secrets and a definition of such acts (40%). Thus, firms want clarity on what is protected and which acts are prohibited by law regarding misappropriation of trade secrets. Firms also want clear rules on criminal sanctions and/or fines for individuals and organisations responsible for misappropriation of trade secrets (30%), rules on calculation of damages (30%), and rules ensuring the confidentiality of the trade secrets during the court proceedings (30%). Further, they want uniform contractual rules on non-compete and

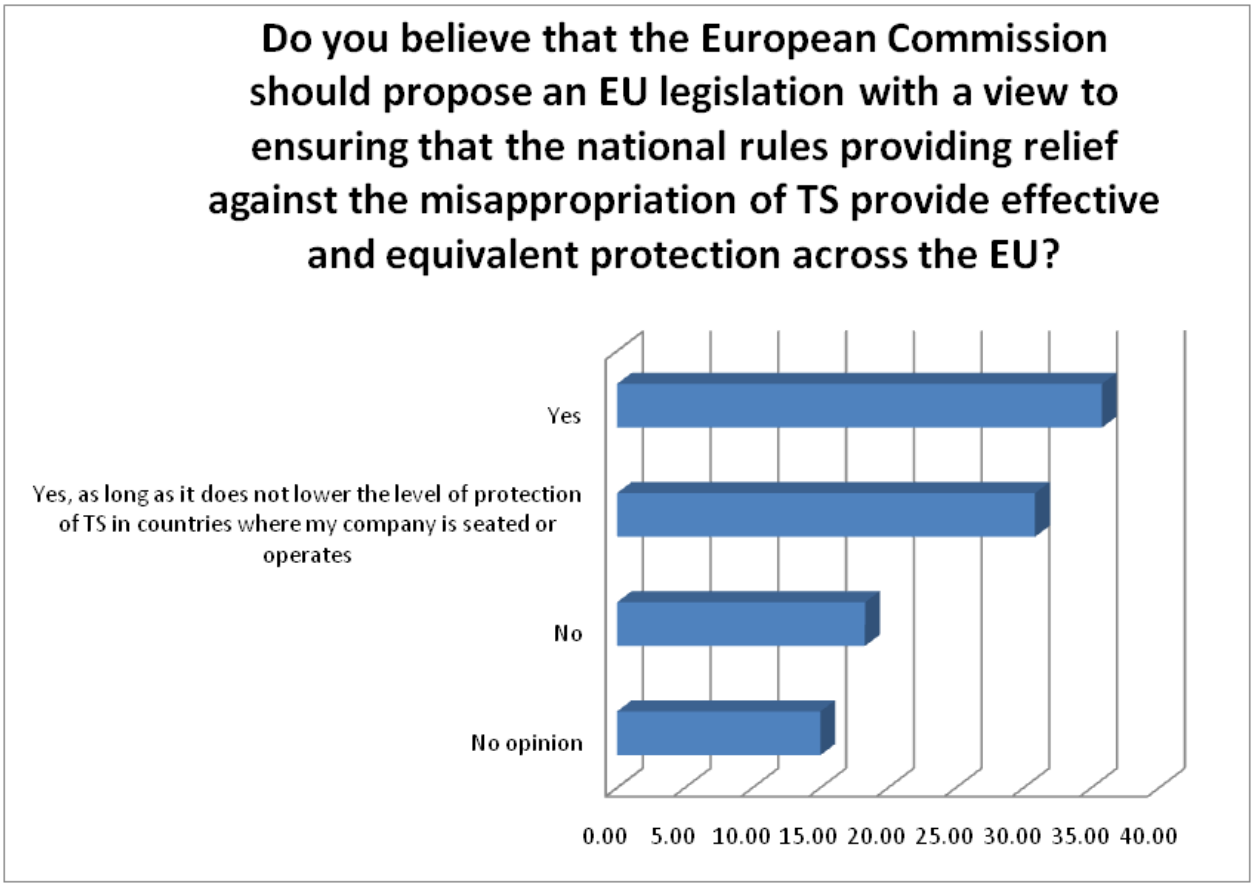

Figure 4.19: Should the European Commission should propose an EU legislation with a view to ensuring that the national rules providing relief against the misappropriation of TS provide effective and equivalent protection across the EU?

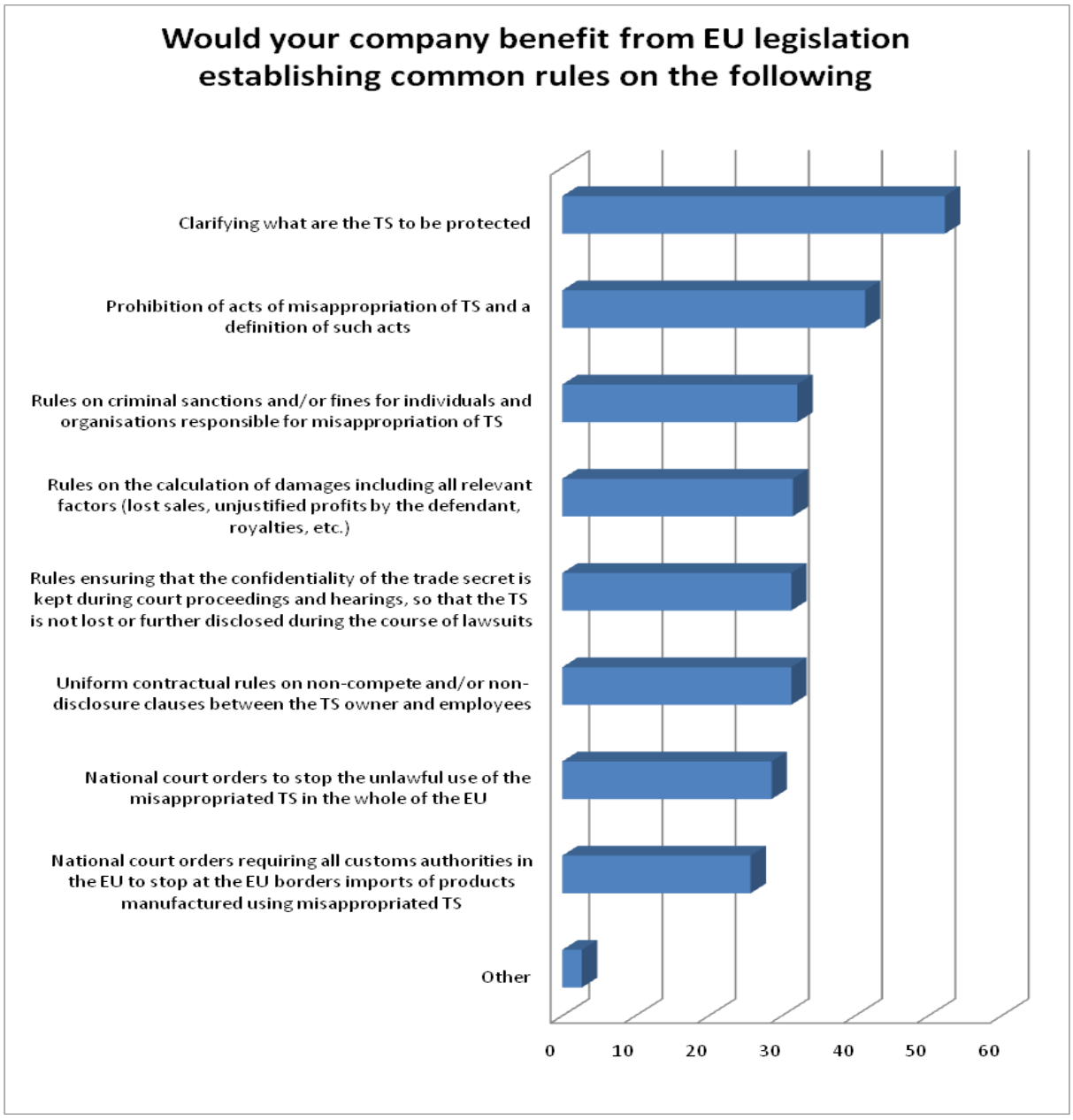

Figure 4.20: Whether companies benefit from common legal rules on protection of TS in the EU

non-disclosure clauses between the trade secret owner and his/her employees (30%) and applicability of national court orders to stop the unlawful use of the misappropriated trade secrets in the whole of the EU (28%). Lastly, they want national court orders requiring all custom authorities in the EU to stop the movement of products using misappropriated trade secrets at the borders (22%).

We look at the perceived positive and negative effects for companies from possible EU common rules on the protection of trade secrets from misappropriation. Figures 4.21 and Figure 4.22 present the perceived positive and negative effects from common EU rules for the firms.

On the positive side of having common rules, the firms believe that their trade secrets would be better protected as the new rules are expected to be a deterrent to misappropriation (45%), they also think that they will have greater legal certainty and lower costs of litigation in other member states (39%). However, around 21% of the firms perceive no positive effects of having a common law. Some firms also think that they would spend less resources for their company specific trade secrets protection measures with the possible EU common rules (20%). Further, they perceive having better opportunities to cooperate with other players for R&D and innovation processes, i.e. network/collaborative innovation as opposed to in-house innovation (18%), and they expect higher incentives to invest in R&D and innovation due to a safer business environment (16%). Around 15% of the firms believe that they would have greater returns from sharing, licensing or transferring know-how and nearly 11% of the firms expect better conditions for accessing funding and venture capital if the proposed common law for protection of trade secrets against misappropriation is created.

Finally, we look at the perceived negative impacts from the possible EU common

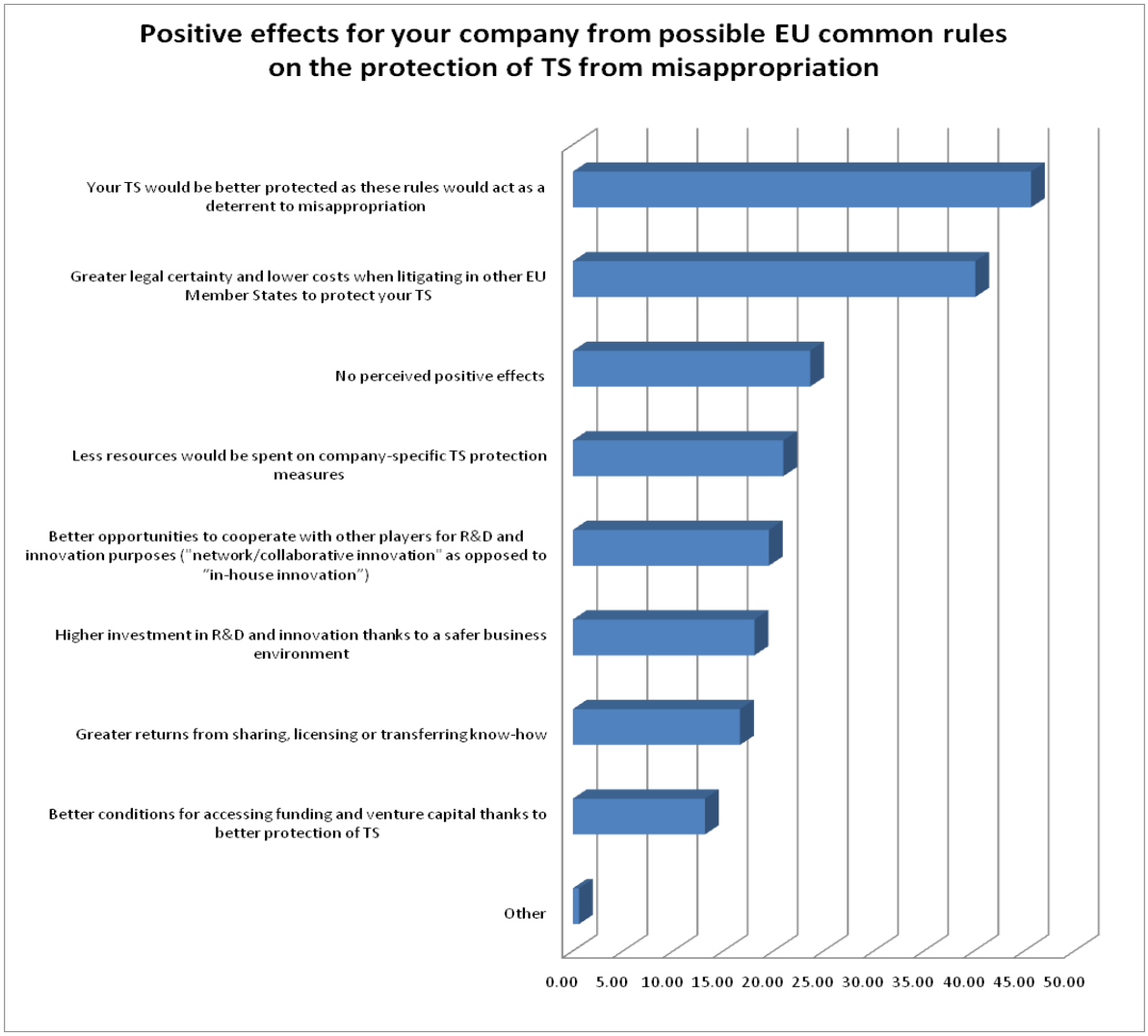

Figure 4.21: Perceived positive effects for companies from possible EU common rules on the protection of TS from misappropriation

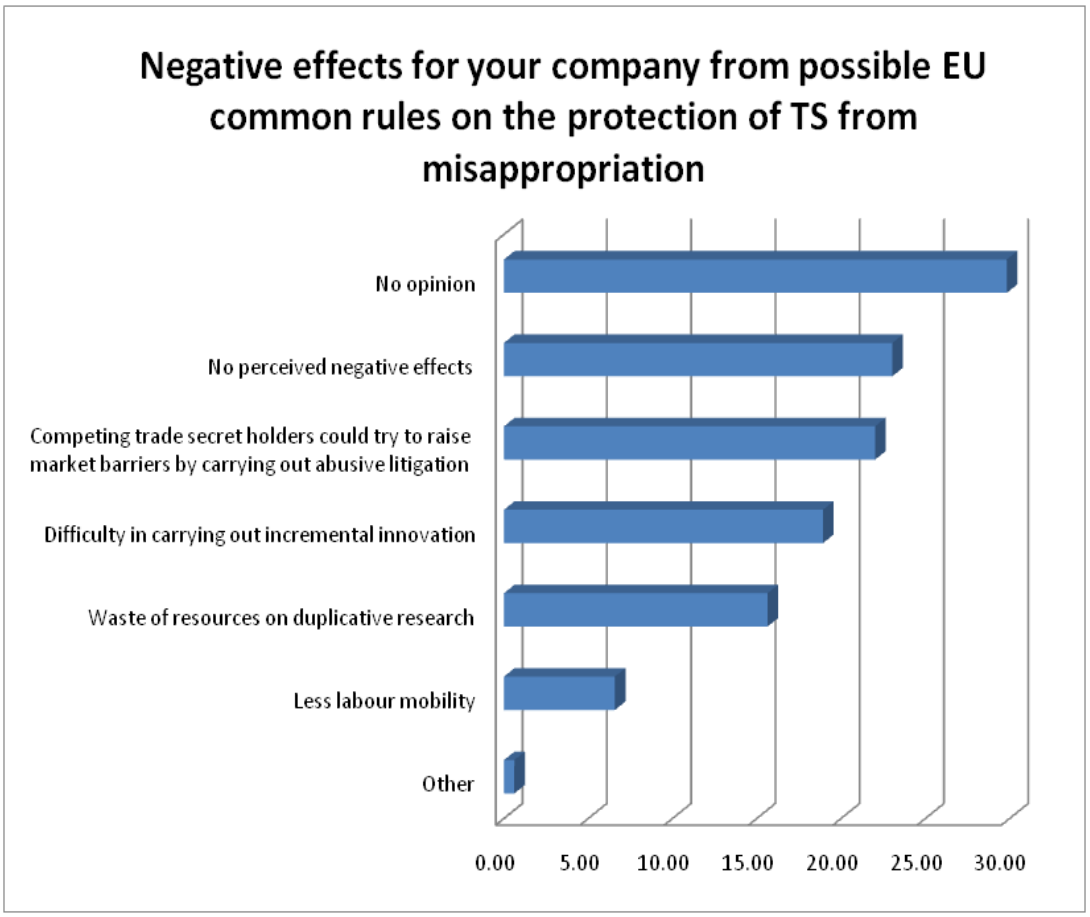

Figure 4.22: Perceived negative effects for companies from possible EU common rules on the protection of TS from misappropriation

rules. Figure 4.22 presents the responses of the firms. Most firms have no opinion regarding the negative impacts (28%), around 23% of the firms perceive no negative effects from the common rules, nearly 22% of the firms think that the competing trade secret holders may try to raise market barriers by carrying out abusive litigation, and nearly 18% of the firms fear difficulty in carrying out incremental innovation due to the possible common rule in the EU. Some firms also think that it may lead to waste of resources on duplicative research (15%) and believe that it may lead to less labour mobility as well (6%).

We looked at the questions of risk of misappropriation of trade secrets, difficulties in proceeding legal actions due to different rules in different countries, reasons for not using courts in EU member states, and the potential advantages/disadvantages of having a common EU legislation for the protection of trade secrets. The risk of misappropriation is reported to have remained constant during last 10 years for most of the firms. Only a small fraction of the firms apply different trade secrets protection measures in different countries (15%). Interestingly, most of the firms did not seek legal remedies if they faced misappropriation in the last 10 years, whereas approximately one third of them sought legal remedies in courts located in EU member states. The firms which sought legal remedies within the EU were able to obtain criminal sanctions against perpetrators, award of damages and court orders stopping the unlawful use of the misappropriated secrets. Most of the firms that obtained protection from one member state were able to enforce protection in other member states as well. However, some of the firms could not enforce the decision granted by one member state in other member states because of the uncertainty of the results in other member states. The reasons for firms not seeking legal remedies in the EU region are mostly represented by the difficulties in collecting evidences, litigation costs, the

fear of public attention and inability to quantify damages etc. We also note that firms consider it beneficial to have a potential uniform legal protection across all member states in the EU, specially in terms of having clarity on what kind of trade secrets can be protected, definition of acts of misappropriation of trade secrets, clear rules for calculation of damages etc. However, some firms have expressed concerns over some of the potential negative impacts too. For instance, firms fear abusive litigation, difficulty in carrying out incremental innovation, waste of resources on duplicative research and a lower labour mobility. These details point towards a need to build a better legal system for the protection of trade secrets against misappropriation in the EU.

The description of the issues described in this section provided detailed characteristics of the themes closely related to the central theme of this chapter, i.e. trade secrets sharing and misappropriation. This provided a clearer picture of firms' perceived risk of misappropriation during the last decade. This description also provides the firms' preferences for a common and stronger protection framework for trade secrets. This shows that firms feel the need of a stronger protection across the European Union.

In later sections we look at the relationship between the importance of trade secrets for their technical, business and innovative information and their reliance on patents. We also look at the possible relationship between information sharing and the importance of trade secrets for the firms. Finally, we try to understand the potential relationship between trade secrets information sharing of the firms and misappropriation of its secret knowledge.

The next section presents the methodology used for the econometric analysis.

4.5 Econometric Methodology

Since most of the questions asked in the questionnaire are qualitative, where the respondents had to choose between different categories, we may use an ordinal logit model for econometric analysis. For instance, one of the questions to focus on here is about the importance of trade secrets for the competitiveness/innovative growth performance of the companies, where the responses can be: low, medium and high. These responses are ordinal in nature, and hence we use an ordinal logit model to analyse this dataset.

The ordinal logit model is widely used to analyse the responses of opinion surveys, involving responses in categories which are ordinal in nature (Zavoina and Mckelvey, 1975). For instance, when the outcome of the opinion survey is coded as 0, 1, 2 ,3 etc., simple linear regression would treat the difference between any two answers as equal, whereas they are just ranking. For these responses we may use ordinal logit model. The model is built around a latent regression in the following way (see Greene W, 2003 and Wooldridge J, 2002). Let y be an ordered response with values, $\{1, 2, 3...J\}$ for some unknown integer J. We may then derive the standard ordered logit model as follows:

$$y^* = x\beta + \epsilon$$

where y^* is unobserved. Let $\alpha_1 < \alpha_2 ... < \alpha_J$ be the unknown threshold parameters, and define

$$y = 0 \text{ if } y^* \leq \alpha_1$$

$$y = 1 \text{ if } \alpha_1 < y^* \leq \alpha_2$$

$$y = 2 \text{ if } \alpha_2 < y^* \leq \alpha_3$$

.....

$$= J \text{ if } y^* > \alpha_J$$

which is a kind of censoring. It may be noted that for three categories, 0, 1, 2, we would have two threshold points, α_1 and α_2. The respondents have their preferences over the alternative categories of responses, which depend on certain observable factors x, and some unobservable factors ϵ (with logistic distribution). The respondents cannot report their y^* directly in the survey because there are given ordinal scales, so they choose the one which is close to their own opinion, y^*.

In total, we estimate 9 models, which are as follows:

The independent variables for the first three models are the same, and the dependent variables are the importance of trade secrets for the firms' competitiveness/innovative growth, technical information and their business information. The dependent variables for models (1), (2) and (3) are as follows:

(1) For the first model, $IMPinnov = x\beta + \epsilon,$ where $IMPinnov$ represents the importance of trade secrets for competitiveness/innovative growth performance of the firms, which takes on the value 1 for low importance, 2 for medium importance and 3 for high importance.

(2) For the second model, $IMPtech, = x\beta + \epsilon$, where $IMPtech$ represents the importance of trade secrets for technical information of the firms, which takes on the value 1 for low importance, 2 for medium importance and 3 for high importance[14].

(3) For the third model, $IMPbuss = x\beta + \epsilon$, where $IMPbuss$ represents the importance of trade secrets for business information of the firms, which takes on the value 1 for low importance, 2 for medium importance and 3 for high importance[15].

The independent variables for these three models are the following:

a) Medium Patent Usage Dummy: It takes on the value 1 if the firms report medium reliance on patents, else zero.

b) High Patent Usage Dummy: It takes on the value 1 if the firms report high reliance on patents, else zero.

c) Multinational Dummy: It takes on the value 1 if the firm happens to be multinational, else zero.

d) Short Life-Cycle Dummy: It takes on the value 1 if firms produce the products having a short life (less than 2 years).

e) Manufacturing Dummy: It takes on the value 1 if the firm's principal activity happens to be manufacturing (all kinds of manufacturing from Table 4.1), else zero.

f) Small Firms Dummy: It takes on the value 1 if firm has less than 50 employees,

---

[14]We constructed the variable importance of TS for technical information based on the subcategories of technical information. There were four categories of technical information, namely, R&D data; process know-how and technology; formulae and recipes; and product technology, with each of them receiving value 1 for low importance, 2 for medium importance and 3 for high importance. We add these four values and divide them in three categories based on their sum, similar to each of them as low, medium and high.

[15]We constructed the variable importance of TS for business information based on the subcategories of business information. The variable for importance of TS for business information included four categories, namely, customer or supplier lists and related data; commercial bids, contracts and contractual terms; marketing data and planning (advertising, market surveys, sales figures and forecasts); and financial information & buisenss planning. The importance of TS for business information is then divided in three categories; low, medium and high, as for the importance of technical information.

in line with the OSLO manual.

g) Medium Firms Dummy: It takes on the value 1 if firm has less than 50-249 employees, in line with the OSLO manual.

h) Country Dummies: We include country dummies[16] to take care of country specific effects. Country dummies are used with a reference category France. The choice was random, however, it may be noted that trade secrets are considered as intellectual property in France. The firms which report being the firms outside the sampled countries, have been put under a banner "others".

For model (4), we have $Infosharing = x\beta + \epsilon$, where $Infosharing$ represents trade secrets or commercial business information sharing of the firms with third parties through contracts or other arrangements like know-how transfer licensing of unpatented technology and services know-how etc. The variable takes on the value 1 if the firms never share their trade secrets information, 2 for occasional trade secrets sharing and 3 for regular trade secrets sharing. The independent variables for model (4) are as follows:

a) Medium importance of secrecy for innovativeness and competitive growth dummy: It takes on the value 1 if firms report medium importance of trade secrets for innovativeness and competitive growth of their firms, else zero.

b) High importance of secrecy for innovativeness and competitive growth dummy: It takes on the value 1 if firms report high importance of trade secrets for innovativeness and competitive growth of their firms, else zero.

c) Multinational Dummy: It takes on the value 1 if the firm happens to be multinational, else zero.

[16] A dummy variable is a numerical variable used in regression analysis to represent subgroups of the sample in an empirical study. For instance, France is the reference category for our regression analysis. In terms of running regression, it means that all countries except France were kept in regression. Thus, the cofficients of all other countries can be interpreted with respect to France.

d) Short Life-Cycle Dummy: It takes on the value 1 if firms produce the products having a short life (less than 2 years).

e) Manufacturing Dummy: It takes on the value 1 if the firm's principal activity happens to be manufacturing (all kinds of manufacturing from Table 4.1), else zero.

f) Small Firms Dummy: It takes on the value 1 if firm has less than 50 employees, in line with the OSLO manual.

g) Medium Firms Dummy: It takes on the value 1 if firm has less than 50-249 employees, in line with the OSLO manual.

h) Country Dummies: We include country dummies to take care of country specific effects. Country dummies are used with a reference category France. The choice was random, however, it may be noted that trade secrets are considered as intellectual property in France. The firms which report being the firms outside the sampled countries, have been put under a banner "others".

For model (5), the dependent variable remains the same as of model (4), we just replace the independent variables a) and b) of the model (4) with medium importance of secrecy for technical information, and high importance of secrecy for technical information, which take on the value 1 if the firms report medium and high importance of trade secrets for technical information respectively, else zero. All other independent variables remain the same as of model (4). Similarly, for model (6), with the same dependent variable, we replace the independent variables a) and b) of model (4) with medium importance of secrecy for business information, and high importance of secrecy for business information, which take on the value 1 if the firms report medium and high importance of trade secrets for business information respectively, else zero. All other independent variables remain the same as of model (4).

Finally, the models for finding the relationship of the misappropriation of trade

secrets and information sharing, and the relationship of the misappropriation of trade secrets and the perceived importance of trade secrets are given by models (7), (8) and (9).

For model (7), we have $Misapp = x\beta + \epsilon$, where $Misapp$ represents misappropriation of trade secrets, which takes on the value 2 if the firm has faced misappropriation more than 5 times inside the EU, or outside the EU, 1 if it faced lower than 5 incidences in both inside and outside the EU, with at least one incidence of misappropriation in either inside the EU or outside the EU; and the value 0 if it faced no incidence of misappropriation. The independent variables are the following:

a) Medium importance of secrecy for innovativeness and competitive growth dummy: It takes on the value 1 if firms report medium importance of trade secrets for innovativeness and competitive growth of their firms, else zero.

b) High importance of secrecy for innovativeness and competitive growth dummy: It takes on the value 1 if firms report high importance of trade secrets for innovativeness and competitive growth of their firms, else zero.

c) Occasional information sharing dummy: It takes on the value 1 if the firms share information occasionally, else zero.

d) Regular information sharing dummy: It takes on the value 1 if the firms share information regularly, else zero.

e) Multinational Dummy: It takes on the value 1 if the firm happens to be multinational, else zero.

f) Short Life-Cycle Dummy: It takes on the value 1 if firms produce the products having a short life (less than 2 years).

g) Manufacturing Dummy: It takes on the value 1 if the firm's principal activity happens to be manufacturing (all kinds of manufacturing from Table 4.1), else zero.

h) Small Firms Dummy: It takes on the value 1 if firm has less than 50 employees, in line with the OSLO manual.

i) Medium Firms Dummy: It takes on the value 1 if firm has less than 50-249 employees, in line with the OSLO manual.

j) Country Dummies: We include country dummies to take care of country specific effects. Country dummies are used with a reference category France. The choice was random, however, it may be noted that trade secrets are considered as intellectual property in France. The firms which report being the firms outside the sampled countries, have been put under a banner "others".

For model (8), the dependent variable remains the same as of model (7), we just replace independent variables a) and b) of model (7) by medium importance of secrecy for technical information and high importance of secrecy for technical information respectively. All other independent variables remain the same as of model (7). Similarly, for model (9), the dependent variable remains the same as model (7), whereas the variables a) and b) of model (7) are replaced by medium importance of secrecy for business information and high importance of secrecy for business information respectively. All other independent variables remain the same as of model (7).

We now move to the empirical analysis where we perform econometric analysis of the models described above. We look at the importance of trade secrets for technical information, business information and innovative growth of the firms, trade secrets sharing and misappropriation of trade secrets with various independent variables.

4.6 Empirical Analysis

As discussed in the previous sections, the main question of interest is whether firms having higher trade secrets information sharing face a higher probability of misappropriation of a trade secret. It has implications for the law-makers if they want faster diffusion of knowledge. They may devise stricter laws to promote and protect information sharing among firms. We first focus on the factors that affect information sharing among firms.

Is information sharing bad for owners of trade secrets? Or, how does trade secret sharing give rise to misappropriation incidences? Do firms face a higher incidence of misappropriation if they share information regularly among each other? Safer trade secrets sharing can be advantageous for firms to advance their technical know-how. However, weaker trade secret law may be conducive to misappropriation behaviour of trade secrets. This is also related to Arrow's information paradox, which some legal scholars claim to have been partially solved with trade secrets law (Lemley 2008). Even with the current laws, if firms observe misappropriation with higher information sharing, it may be the result of Arrow's explanation, or probably the laws are too weak to protect information among the voluntarily information sharing parties.

4.6.1 Importance of Trade Secrets for technical information, business information and the innovative growth of firms

Firstly, we look at how the importance of trade secrets depends on various firm specific characteristics, like, size of the firm, whether it is a multinational firm,whether it is a manufacturing firm and whether firms' products are characterised by a short life term or not. Further, the importance of secrecy is regressed on the usage of patents by the

firm, in light of the possible substitutability or complementarity between the two in the existing literature (Ottoz and Cugno, 2008), and country dummies are included to look for possible differences among the countries in terms of importance of secrecy. The dependent variables used are valuation of firms given to secrecy for technical information, business information and innovativeness and competitive growth of the firms. All three dependent variables take on the value 1 for low valuation of secrecy, 2 for medium importance of secrecy and 3 for high importance of secrecy by the firms, as described in the Econometric Methodology section. An ordinal logit regression is performed for understanding the association between importance of secrecy and various variables considered.

Before the discussion of the results, first we describe the expected results from this econometric exercise. For models (1), (2) and (3), the dependent variables are the perceived importance of trade secrets for innovative and competitive growth of the firms, the importance of trade secrets for their technical information and the importance of trade secrets for their business information. The independent variables are common to all three models and we expect their coefficients to have the following signs:

a) Medium Patent Usage Dummy: We would expect this to have a positive relation with the importance of trade secrets for all three models, because of the complementarity of secrecy and patents, as argued by several researchers (e.g. Jorda, 2008, Ottoz and Cugno, 2008, 2011). The reference category used for this dummy is low patent usage, so the firms which have medium usage of patents, as compared to the firms with low usage are expected to consider trade secrets to be more important. Thus, for models (1), (2) and (3) we expect a positive and significant sign with this variable.

b) High Patent Usage Dummy: Similar to the medium patent usage dummy, we

expect this to have a positive and significant sign. Again, the reference category is low patent usage, thus, firms that have a high reliance on patents are expected to have higher importance of trade secrets for innovative growth of their firms, for their technical information and for their business information.

c) Multinational Dummy: For multinational firms, we expect the coefficient to have a positive sign, because firms that are multinational are expected to have better technology with them. We would generally expect multinational firms to have a bigger portfolio of intellectual assets, and thus may expect them to consider trade secrets to be important for their critical information such as their innovative knowledge, technical information and business information.

d) Short Life-Cycle Dummy: If a firm produces goods which generally have a short life cycle, then we may expect them to put a lower importance on trade secrets. This is because firms producing products with a life-cycle lower than 2 years might not need to maintain secrecy because of the costs associated with maintaining trade secrets. Therefore, we would generally expect a negative sign of the coefficient of this variable.

e) Manufacturing Dummy: For technical information and innovative knowledge, we would expect manufacturing firms to have a positive relationship with importance of trade secrets. This is because manufacturing firms are expected to be technology driven and to maintain technology they might consider trade secrets to be important. Gonzalez-Alvarez and Nieto-Antolin (2007), focusing on Spanish manufacturing firms, find that firms that are characterised by high usage of implicit knowledge, consider secrecy to be important. Manufacturing firms are expected to be technically oriented and thus might consider trade secrets to be important. For business information on the other hand, the link does not seem to be very clear.

f) Small Firms Dummy: We expect this coefficient to be negative because the reference category is large firms, and the small firms are expected to consider trade secrets to be less important as compared to the large firms.

g) Medium Firms Dummy: Similarly we expect this coefficient to be negative because when compared to large firms, medium firms are probably expected to find trade secrets less important.

h) Country Dummies: We include country dummies to take care of country specific effects. The reference category is kept to be France. We may expect other countries to differ positively or negatively as compared to France in terms of importance they put on trade secrets.

Now, we turn to the regression outcomes for models (1), (2) and (3). Table 4.4 presents the results of ordinal logit regression of importance of trade secrets for innovative growth and competitiveness, technical information and business information of the firms surveyed. We find that firms that make high use of patents (in relation to the firms who have low usage of patents) are more likely to value secrecy highly, as interpreted with a positive and significant coefficient of "High Patent Usage" for all kinds of areas. We also note that small and medium sized firms are less likely to value secrecy highly as compared to large sized firms for the innovative growth and competitiveness of the firms, interpreted from a negative and significant sign. It is also observed that multinational firms are likely to value secrecy highly for technical information. Furthermore, it is noted that there are some differences among countries in terms of valuation that firms give to secrecy, as suggested by significant coefficients of some countries (the reference category being France). Another interesting outcome of this regression is that manufacturing firms are more likely to value secrecy highly for technical information, whereas for business information, they are less likely to

value secrecy highly as compared to non-manufacturing firms. It is intuitive because manufacturing firms are expected to care more about technological secret information as compared to the non-manufacturing firms which may value secrecy more for business information.

Most of the findings of the econometric analysis are consistent with the expected outcomes. For instance, we see a clear complementarity between the use of trade secrets and patents for all three models analysed here. Firms that rely heavily on patents heavily seem to consider trade secrets important for their innovative growth, technical information and business information. Manufacturing firms are found to consider trade secrets to be important for their technical information, as interpreted from the positive sign of its coefficient. However, they do not seem to consider trade secrets to be important for their innovative growth, as seen from its insignificant coefficient in the regression result. The negative coefficient for the importance of business information seems to suggest that manufacturing firms do not consider trade secrets to be important for their business information. The size of the firms seems to matter as far as importance of trade secrets for innovative growth is concerned. It turns out that small and medium sized firms (as compared to large firms) consider trade secrets to be less important for innovative growth of their firms. Firms that produce short life-cycle products, that is their product's life is shorter than 2 years, do not consider trade secrets to be important for their innovative growth, whereas it seems to have no relation with the importance of trade secrets for their technical and business information.

4.6.2 Information Sharing and Instances of Misappropriation of Trade Secrets

Regressors	**Importance of TS for Innovative Growth**	**Importance of TS for Technical Information**	**Importance of TS for Business Information**
	(1)	**(2)**	**(3)**
Medium Patent Usage	0.311	1.101***	0.543*
	(0.272)	(0.277)	(0.281)
High Patent Usage	**1.664*** **	**2.624*** **	**1.713*** **
	(0.285)	**(0.351)**	**(0.336)**
Multinational Dummy	-0.115	0.566**	0.083
	(0.252)	(0.284)	(0.285)
Short Lifecycle Dummy	-0.457**	-0.114	0.269
	(0.232)	(0.255)	(0.257)
Manufacturing Dummy	-0.138	0.645**	-0.561**
	(0.238)	(0.271)	(0.262)
Small firms dummy	-0.675**	-0.538*	-0.340
	(0.287)	(0.307)	(0.307)
Medium firms dummy	-0.599**	0.312	0.495
	(0.294)	(0.348)	(0.347)
Country Dummies (Reference category France)			
Austria	1.410**	-0.566	0.276
	(0.588)	(0.635)	(0.681)
Belgium	0.515	0.518	0.149
	(0.602)	(0.693)	(0.701)
Czech Republic	-0.267	0.033	-0.342
	(0.592)	(0.664)	(0.670)
Germany	1.429**	0.474	0.420
	(0.661)	(0.697)	(0.746)
Hungary	1.347**	0.649	0.375
	(0.586)	(0.688)	(0.705)
Italy	1.044*	1.450**	0.051
	(0.575)	(0.691)	(0.660)
The Netherlands	0.094	-0.543	-0.815
	(0.632)	(0.690)	(0.703)
Poland	-0.069	-0.193	-0.834
	(0.636)	(0.727)	(0.724)
Spain	1.129**	0.638	0.475
	(0.576)	(0.659)	(0.697)
Sweden	0.655	-0.150	-0.306
	(0.589)	(0.641)	(0.658)
Switzerland	-0.291	-0.088	0.389
	(0.597)	(0.675)	(0.741)
Great Britain	1.027	-0.005	-0.593
	(0.678)	(0.716)	(0.734)
Others	16.539	15.668	14.601
	(827)	(911)	(973)
No. of Observations	351	368	368
LR chi2(33)	95.47	148.36	66.34
Prob > chi2	0.000	0.000	0.000
Pseudo R2	0.135	0.221	0.113
Note: Standard Errors are in brackets. Significance at 1% ***, at 5% **, at 10% *			

Table 4.4: Ordinal Logit: Importance of TS for technical information, business information and innovative growth and competitiveness of firms and usage of patents

Next we look at the sharing of trade secrets by the firms and its potential relationship with the importance of trade secrets for innovative growth and competitiveness, technical information and business information of the firms. Table 4.5 presents the ordered logit regression of models (4), (5) and (6), that is regressing trade secrets information sharing by the firms on the importance of secrecy for innovative growth and competitiveness of the firms, of technical information and of business information, and various other firms' characteristics; whether the firm is a multinational, whether the products it produces are characterised by a short life cycle, whether it happens to be a manufacturing firm and the size of the firms.

We first discuss the expected relationships of the variables with trade secrets sharing. For model (4), (5) and (6), except for the first two independent variables, all other variables are the same. We denote the first two variables of model (4); (5); and (6) by 4.a) and 4.b); 5.a) and 5.b); and 6.a) and 6.b) respectively. After describing the first two independent variables of all these models, we will describe all other variables which are common to all these models. We have:

4.a) Medium importance of secrecy for innovativeness and competitive growth: We expect this to have a positive sign in the regression result because firms that consider trade secrets to be important for their innovative growth are expected to have a bigger portfolio of secret knowledge and thus may indulge in the optimum usage of their trade secrets by sharing it with their partners. Firms regularly acquire external knowledge and share their technology (Quintas et. al., 1997).

4.b) High importance of secrecy for innovativeness and competitive growth: Similarly, firms that give high importance to trade secrets (as compared to those firms that give low importance) are expected to share information with external parties to optimally use their secret knowledge and gain critical knowledge of other firms.

5.a) Medium importance of secrecy for technical information: For technical information as well, we expect a positive and significant sign because firms that consider trade secrets to be important for their technical information are expected to share their secret information and obtain the critical knowledge of other firms.

5.b) High importance of secrecy for technical information: Again, we expect a positive sign for the similar reasons mentioned above.

6.a) Medium importance of secrecy for business information: It is not clear whether firms may want to share their business information with external parties or not. We may expect an insignificant relationship between medium importance of secrecy for business information and trade secrets sharing behaviour of the firms.

6.b) High importance of secrecy for business information: Similar to the medium importance, we expect an insignificant relationship between this variable and trade secrets sharing behaviour of the firms.

All other independent variables are same for all these three models which are:

c) Multinational Dummy: For multinational firms, we expect the coefficient to have a positive sign, because firms that are multinational are expected to have more technology partners across borders and access to better technology.

d) Short Life-Cycle Dummy: For the firms that produce goods with a short life-time, we would not expect them to share trade secrets with external parties because they might not maintain a portfolio of secret information. In fact, secrecy is important for the firms only if it can be maintained for a reasonable amount of time. If the firms' products do not last long, there may be no demand of their trade secrets knowledge. Thus, we may expect an insignificant relationship with this variable.

e) Manufacturing Dummy: Manufacturing firms are generally technology centered and thus may share trade secrets information with their partners in the industry. We

may expect a positive sign of this variable.

f) Small Firms Dummy: We expect this coefficient to be negative because the reference category is large firms, and the small firms are expected to share less information as compared to the large firms. Large firms are generally expected to have a big trade secrets portfolio and better technology transfer collaborations. Thus we expect the sign to be negative for small firms dummy.

g) Medium Firms Dummy: Similarly we expect this coefficient to be negative because when compared to large firms, medium firms are probably less expected to share their trade secrets.

h) Country Dummies: We include country dummies to take care of country specific effects. The reference category is kept to be France. We may expect other countries to differ positively or negatively as compared to France in terms of sharing of trade secrets among firms.

From the results, we interpret that firms are more likely to share secret information with third parties (using know-how transfer, licensing of unpatented knowledge etc.) if they put medium or high value to the use of secrecy for innovative knowledge in their firms. Further, small firms are less likely to share secret information as compared to large firms, as suggested by a negative and significant coefficient. Again most of the results are in line with the expected outcomes. However, we find that the importance of trade secrets for technical information and business information are not significantly related to the trade secrets sharing behaviour. Probably firms share the information which affects their innovativeness and not their technical and business information with external parties. This may happen due to the need for trade secrets sharing to develop inventive knowledge whereas sharing trade secrets for technical information and business information may not be beneficial for the firms.

Dependent Variable: TS information Sharing			
	(4)	(5)	(6)
Medium importance of Secrecy for innovativeness and competitive growth	0.676**		
	(0.276)		
High importance of secrecy for innovativeness and competitive growth	0.908***		
	(0.301)		
Medium importance of Secrecy of technical information		0.390	
		(0.325)	
High importance of secrecy of technical information		0.309	
		(0.304)	
Medium importance of Secrecy of business information			0.104
			(0.400)
High importance of secrecy of business information			0.240
			(0.380)
Multinational Dummy	0.285	0.450**	0.444**
	(0.218)	(0.208)	(0.206)
Short Lifecycle Dummy	-0.039	0.079	0.077
	(0.199)	(0.187)	(0.186)
Manufacturing Dummy	-0.281	-0.254	-0.220
	(0.205)	(0.196)	(0.195)
Small firms dummy	-0.623***	-0.724***	-0.709***
	(0.244)	(0.226)	(0.225)
Medium firms dummy	-0.353	-0.383	-0.373
	(0.256)	(0.248)	(0.247)
Country Dummies (Reference category France)			
Austria	0.509	0.561	0.554
	(0.526)	(0.491)	(0.491)
Belgium	0.081	0.175	0.180
	(0.521)	(0.494)	(0.494)
Czech Republic	0.321	0.531	0.553
	(0.513)	(0.488)	(0.488)
Germany	-0.496	-0.325	-0.348
	(0.571)	(0.528)	(0.528)
Hungary	-0.851	-0.391	-0.396
	(0.522)	(0.490)	(0.489)
Italy	-0.160	0.093	0.109
	(0.490)	(0.465)	(0.462)
The Netherlands	0.474	0.441	0.442
	(0.544)	(0.511)	(0.511)
Poland	0.216	0.235	0.215
	(0.530)	(0.495)	(0.494)
Spain	0.623	1.056**	1.057**
	(0.516)	(0.492)	(0.492)
Sweden	0.413	0.532	0.591
	(0.514)	(0.486)	(0.484)
Switzerland	0.257	0.643	0.640
	(0.522)	(0.497)	(0.497)
Great Britain	-0.535	-0.453	-0.426
	(0.584)	(0.541)	(0.540)
Others	0.655	1.101	1.071
	(0.826)	(0.748)	(0.747)
No. of Observations	433	486	486
LR chi2(36)	45.68	50.25	49.45
Prob > chi2	0.0000	0.0000	0.0000
Pseudo R2	0.0516	0.0508	0.0500
Note: Standard Errors are in brackets. Significance at 1% ***, at 5% **, at 10% *			

Table 4.5: Ordinal Logit: TS sharing with external parties and importance of TS for innovative growth and competitiveness, technical information and business information

For a safer sharing of inventive knowledge among firms, a strong legal protection against potential improper acquisition of trade secrets by external parties is required. Next we look at the relationship between information sharing and misappropriation of trade secrets, and the importance of trade secrets and their misappropriation. This will help us understand the probability of firms facing misappropriation if they share their trade secrets with external agents. This will have a direct policy implication regarding strengthening of trade secrets laws against improper acquisition of secrets of the firms. There was a question in the survey regarding the misappropriation instances during last 10 years, both within the EU region and outside the EU region.

We first discuss the expected relationships of the variables with incidences of misappropriation. For model (7), (8) and (9), except for the first two independent variables, all other variables are the same. We denote the first two variables of model (7); (8); and (9) by 7.a) and 7.b); 8.a) and 8.b); and 9.a) and 9.b) respectively. After describing the first two independent variables of all these models, we will describe all other variables which are common to all these models. We have:

7.a) Medium importance of secrecy for innovativeness and competitive growth: We expect this to have a positive sign in the regression result because firms that consider trade secrets to be important for their innovative growth are expected to have a large portfolio of secret knowledge and thus may indulge in collaborations with external parties, which may lead to possible misappropriation of their secrets.

7.b) High importance of secrecy for innovativeness and competitive growth: Similarly, firms that give high importance to trade secrets (as compared to those firms that give low importance) are expected to share information with external parties, and thus face higher risk of misappropriation.

8.a) Medium importance of secrecy for technical information: For technical infor-

mation as well, we expect a positive and significant sign because firms that consider trade secrets to be important for their technical information are expected to indulge in trade secrets sharing with other firms. Thus they may face higher misappropriation chances.

8.b) High importance of secrecy for technical information: Again, we expect a positive sign for the similar reasons mentioned above.

9.a) Medium importance of secrecy for business information: It is not clear whether firms may want to share their business information with external parties, and thus they may not face incidences of misappropriation. We may expect an insignificant relationship between medium importance of secrecy for business information and trade secrets sharing behaviour of the firms.

9.b) High importance of secrecy for business information: With the firms which give high importance to secrecy for business information, we may expect a positive sign because if the value of secrets is high, the employees of the firms, or the competitors may want to misappropriate it.

All other independent variables are the same for all these three models which are:

c) Occasional information sharing dummy: The relationship of trade secrets sharing and its misappropriation is the most important relationship of interest in this chapter. We expect this to have a positive and significant sign because when firms share trade secrets information occasionally (as compared to no trade secrets sharing) with external parties, the chances of misappropriation of their trade secrets are expected to increase.

d) Regular information sharing: We expect this sign to be positive and significant as well. When firms share their trade secrets information on a regular basis they are expected to face a high probability of misappropriation of their secrets. It would be

especially true if the legal system governing trade secrets sharing is weak.

e) Multinational Dummy: For multinational firms, we may expect the coefficient to have a positive sign, because multinational entities are generally spread in many countries and the business environment of different countries may have different chances of facing misappropriation. Further, the trade secrets information might also be spread in many different locations, and thus the chances of misappropriation may be higher.

f) Short Life-Cycle Dummy: We expect this to have a negative coefficient since firms with short life products may not possess high valued secrets, and thus may face lower chances of misappropriation of their trade secrets.

g) Manufacturing Dummy: Manufacturing firms are generally technology centered and may require to share trade secrets with many employees in the process of production. It is expected to increase the possibilities of misappropriation of firms' trade secrets. Thus we may expect a positive sign of this variable.

h) Small Firms Dummy: As compared to large firms, small firms are expected to face lower chances of misappropriation because they may have smaller trade secrets portfolios and thus may protect them better. Thus we expect the sign to be negative for small firms dummy.

i) Medium Firms Dummy: Similarly we expect this coefficient to be negative because when compared to large firms, medium firms are probably less prone to misappropriation.

j) Country Dummies: We include country dummies to take care of country specific effects. The reference category is kept to be France. We may expect other countries to differ positively or negatively as compared to France in terms of misappropriation of trade secrets of the firms.

Table 4.6 represents the regression results. Most of the findings are as expected.

For instance, we find that firms which consider trade secrets for innovativeness and competitive growth to be important are more likely to face misappropriation, given by the positive and significant coefficients for both medium valuing and high valuing firms. Firms having medium and high importance of secrecy for technical and business information are expected to face higher misappropriation as compared to the firms with low importance of trade secrets. Further, the firms sharing trade secrets information are more likely to face misappropriation, suggesting that there might be a need for stronger laws to protect the firms which want to share the secret information. We also find that manufacturing firms, and firms producing products which are characterised by a short life-cycle (less than 2 years) are more likely to face higher incidences of misappropriation.

Overall, we interpret that firms sharing general secret information with other parties are more likely to face misappropriation of their trade secrets. Thus, lawmakers might want to modify the legal system[17] to enhance freer information sharing because diffusion of knowledge is a desirable outcome for the growth of innovative knowledge in general. However, we also note that this should not lead to collusive behaviour among firms. Trade secrets sharing should promote technical advancements without giving rise to collusive behaviour among firms. The competition authorities should pay attention to this possibility. The responses of this survey reveal that firms sharing information with third parties are more likely to face misappropriation as compared to the firms with no information sharing. Thus, the lawmakers may want to enhance the legal set up to allow for more diffusion without firms losing control over their trade secrets.

[17]Note that it is beyond the objective of this paper to suggest the legal instruments which might be used to strengthen the current legal system of protection of trade secrets to reduce misappropriation incidences.

Dependent Variable: Misappropriation of TS			
	(7)	(8)	(9)
Medium importance of Secrecy for innovativeness and competitive growth	0.954** (0.414)		
High importance of secrecy for innovativeness and competitive growth	1.467*** (0.440)		
Medium importance of Secrecy for technical information		1.607*** (0.591)	
High importance of secrecy for technical information		1.475*** (0.575)	
Medium importance of Secrecy for business information			1.584* (0.825)
High importance of secrecy for business information			2.169*** (0.801)
Occasional information sharing dummy	0.733** (0.293)	0.854*** (0.279)	0.881*** (0.279)
Regular information sharing dummy	1.304*** (0.357)	1.352*** (0.345)	1.373*** (0.348)
Multinational Dummy	0.437 (0.273)	0.494* (0.269)	0.506 (0.266)
Short Lifecycle Dummy	0.604** (0.253)	0.450* (0.242)	0.450 (0.242)
Manufacturing Dummy	0.769*** (0.259)	0.622** (0.250)	0.810 (0.254)
Small firms dummy	-0.094 (0.316)	-0.330 (0.305)	-0.215 (0.304)
Medium firms dummy	0.017 (0.320)	-0.123 (0.312)	-0.118 (0.313)
Country Dummies (Reference category France)			
Austria	-1.966*** (0.646)	-1.571** (0.622)	-1.740*** (0.625)
Belgium	-0.798 (0.603)	-0.740 (0.590)	-0.757 (0.588)
Czech Republic	-0.123 (0.572)	-0.041 (0.553)	0.028 (0.554)
Germany	-1.725** (0.710)	-1.165* (0.644)	-1.278** (0.649)
Hungary	-1.680*** (0.623)	-1.461** (0.599)	-1.534*** (0.599)
Italy	-1.855*** (0.597)	-1.611** (0.580)	-1.639*** (0.580)
The Netherlands	-1.187* (0.641)	-1.121* (0.617)	-1.149* (0.618)
Poland	-2.742*** (0.873)	-1.864*** (0.697)	-1.918*** (0.700)
Spain	-2.030*** (0.634)	-1.810*** (0.614)	-1.816*** (0.616)
Sweden	-1.414** (0.630)	-1.263** (0.592)	-1.178** (0.596)
Switzerland	-0.274 (0.598)	-0.274 (0.576)	-0.375 (0.584)
Great Britain	-1.738** (0.789)	-1.720** (0.765)	-1.610** (0.768)
Others	0.306 (0.853)	0.780 (0.775)	0.606 (0.775)
No. of Observations	486	486	486
LR chi2(36)	89.11	92.03	95.79
Prob > chi2	0.0000	0.0000	0.0000
Pseudo R2	0.1454	0.1391	0.1448
Note: Standard Errors are in brackets. Significance at 1% ***, at 5% **, at 10% *			

Table 4.6: Ordinal Logit: Misappropriation of TS, infomation sharing behavior and importance of TS for innovative knowledge and competitiveness for the firms

4.7 Conclusion

In this chapter we looked at the existing empirical literature on Trade Secrets. It is observed that the existing literature studies trade secrets with relation to patents in a general manner. This chapter, however, looks at trade secrets specifically, using a novel survey data. The survey report on trade secrets for the EU (2014) gives an opportunity to look at specific issues of trade secrets in Europe. An econometric analysis is carried out using this data to understand the misappropriation behaviour among the firms in the EU.

Our main findings can be summarised as follows; i) we found that the firms which consider trade secrets to be important also face a higher possibility of facing misappropriation of their trade secrets; ii) we also found that firms that make high use of patents are more likely to consider trade secrets important, which is often argued in the theoretical literature on the relationship between trade secrets and patents (Ottoz and Cugno, 2008; Jorda, 2008); iii) Furthermore, firms that share information (as compared to the ones that do not) with external parties are more likely to face misappropriation.

This points toward a need to protect the diffusion objective of the law makers. If the firms can not share information without the fear of loss of their secrets, the information flow is restricted, and this might be bad for the society as diffusion of knowledge is very important for knowledge advancements. The policy makers may need to redraft the legal system to allow for misappropriation-free transfer of knowledge.

Chapter 5

CONCLUDING THOUGHTS

In this thesis, we analysed law and economic issues revolving around trade secrets. The goal was to analyse the trade secret law and provide policy recommendations. All chapters of this thesis were interconnected because they analyse various aspects of the same subject matter, trade secrets.

Trade secrets is a topic of great importance in both developed and developing countries where the intellectual property regime and enforcement may encourage the use of Trade Secrets over other kinds of protection mechanisms. The field of trade secrets is becoming more and more important in the academic literature because of an increasing number of cases in the media where trade secret regulation has come under the microscope. An effect of the increase in the focus on trade secrets as an academic topic is that theoretical and empirical frameworks have started to be established. However, no academic literature has covered the important topics of: the optimal scope of trade secrets law; damages (lost profits vs. unjust enrichment) in case of miappropriation of trade secrets; and, the actual misappropriation of secrets on European firms. This thesis, in examining trade secrets, looked at these important areas of study. Given the lack of previous research on these topics, the results of the current thesis are particularly important. Indeed, as results from the fourth chapter show, given the actual rate of missapropriation of secrets faced by European firms, policy recommendations formed as a result of this thesis would be well founded.

The second chapter of this thesis presented the analysis regarding the desired strength of trade secrets law. This chapter covered a broad research area which analysed how strong the protection should be. The optimal scope of protection of trade secrets was studied in light of the positive and negative effects of stronger protection on the elasticity of innovation with respect to the strength of trade secrets law. The effects on social welfare were also taken into consideration while analysing the optimal scope. It was shown that there existed a tension between two competing objectives of promoting innovation and facilitating diffusion of knowledge. The optimality required a balance of these two goals. This chapter provided a fundamental rule to determine the optimal scope of trade secrets law. Further, it was shown that markets characterised by a significant degree of product differentiation required weaker protection of trade secrets.

The next core chapter of this thesis, Chapter 3, looked at what happens when the owner of the secret faced misappropriation of her trade secrets. Legal remedies in the case of misappropriation were discussed with a focus on damages. Two damage regimes were compared in terms of their effects on the owner of the secret, competitors and social welfare. This chapter was a logical consequence to the previous one where we discussed the optimal strength of law. The strength of the law has implications for the remedies in case of misappropriation of trade secrets. If the law protecting trade secrets is strong, the remedies are expected to be strong as well. The comparison of the two most used damage regimes, i.e. the lost profits damage regime and the unjust enrichment regime, was carried out using a model of asymmetric information where the owner of the secret did not know whether the duplicator he faced had developed the same secret knowledge by independent research or had misappropriated the secret. The comparison gave useful results in terms of policy implications. For

instance, the policy makers may want to opt for the damage regime which exhibits a lower deadweight loss. After these two core chapters of this thesis, we moved to the third core chapter, Chapter 4, which analysed a novel survey data of European firms econometrically.

The focus of Chapter 4 was on actual misappropriation faced by the European firms. This chapter established a relationship between trade secrets sharing and misappropriation incidences. Using an ordered logistic model, we found that firms that share their trade secrets with third parties were more probable to face misappropriation compared to firms that did not share their trade secrets. We pointed towards possible weakness of the existing trade secrets law because of which firms might be facing misappropriation when they shared the secret information among each other. Several other important relationships were also reviewed. For example, several theoretical papers in this area have established that patents and secrecy are complements to each other rather than being substitutes. We actually tested this hypothesis with the Baker & McKenzie report's survey data and found that firms that have a high use of patents make high use of secrecy as well. Overall, three core chapters of this thesis have essentially focused on three pillars of law and economics of trade secrets, which are:

i) Before the innovation: How to draw boundaries between "what is allowed" and "what is not allowed" while drafting trade secrets law?

ii) After the innovation: Once the owner of the secret loses his secret, what remedies are available? Which damage regime (the lost profits regime or the unjust enrichment regime) provides better protection to the owner of the secret. Which damage regime provides higher ex-post welfare?

iii) Checks on the existing law: Is there any relationship between trade secrets

sharing and misappropriation incidences? Are patents and trade secrets compliments or substitutes?

These three chapters together looked at the central theme of trade secrets law, that is, how to draft the law, how to provide damages in case of misappropriation, and whether the existing laws are weak in terms of providing effective protection against misappropriation. It is noted that the European Commission is strengthening the existing legal protection to trade secret owners by bringing a harmonised protection system across the European Union.

We summarise the results and findings of the core chapters of this thesis as follows.

The second chapter of this thesis analysed the optimal scope of trade secrets law. It was shown that with stronger protection of trade secrets, the secret owner reduced her efforts in keeping the secret and the imitator reduced her efforts in extracting the secret.

Stronger trade secrets law also increases the incentives to innovate by increasing the payoff to the innovative firms. However, it also makes diffusion of innovative knowledge in the society harder. Thus, there exists a conflict between protecting the innovator with stronger protection and promoting dissemination of innovative knowledge. The policy makers must balance these two contrasting objectives in the best possible manner. It was shown that a proper balance between these two objectives depend on the intensity of market competition in the product market, the cost of self-protection by the owner of the secret and secret extraction costs. Optimality requires protection in such a way that the incentives to innovate are not diminished and at the same time diffusion of innovative knowledge is promoted. The model developed in Chapter 2 considered both benefits and costs of a stronger protection. We showed that maximal protection was warranted when product market competition was weak,

cost of self-protection was low and cost of secret extraction was high.

The possibility of horizontally differentiated goods modifies the results in favour of weaker protection as compared to the case of a homogenous goods market. In the case of horizontally differentiated goods, the optimal scope of trade secrets law is thinner. It increases the benefits of entry for the consumers, but also allows firms to charge more. This result has interesting ramifications in the context of unfair competition law. For example, in Germany, courts consider the degree of similitude between the products before delivering their verdicts. The chances of a suit under unfair competition succeeding in court is higher if the products are similar to each other (see de Vrey 2006).

The third chapter of this thesis investigated civil remedies available to the owner of the secret in case of misappropriation. In particular, we analysed alternative damage regimes and their implications on market competition and welfare.

A model of simple oligopoly competition with asymmetric information was developed in Chapter 3. The asymmetry arises in the following sense: the owner of the secret does not know whether the duplicator has introduced a similar product by misappropriating the secret formula, or developed the product by independent research. The possibility of receiving damages affects the payoff to the owner of the secret, and, hence the market outcome. Similarly, the possibility of paying damages affects the payoff of the duplicator who misappropriated the secret. Furthermore, alternative damage regimes affect the market outcomes in a different manner. We concentrated on the lost profit and the unjust enrichment doctrines of damages and analysed their impacts on the behaviour of the owner of the secret and market outcome. The purpose was to compare these alternative regimes and find out the desirability of one over the other in terms of their impacts on the owner of the secret, ex-post welfare and

incentives to misappropriate the secret rather than investing resources to discover it.

The owner of the secret was found to be better off under the lost profit regime whereas the duplicator who developed his product with independent research was found to be better off under the unjust enrichment regime. However, the duplicator who misappropriated the secret could be better off or worse off under either regime, depending on the parameters of the model.

Further, we found that the unjust enrichment regime resulted in higher welfare as compared to that under the lost profit regime. The incentives to misappropriate were expected to be higher or lower under either regime, depending on the degree of accuracy of courts and on the proportion of violators (duplicators who misappropriated the secret). Clear conditions were found under which the lost profits regime provided greater incentives to misappropriate as compared to that under the unjust enrichment regime. Thus, if protection of the secret owner is considered more important than the ex-post welfare by the policy makers, lost profits damage regime is to be preferred. However, the unjust enrichment is better from the perspective of welfare. If the market is characterised by high proportion of misappropriators and courts make correct judgements most of the times, misappropriation incentives are higher under the lost profits regime (the reverse also holds).

The fourth chapter provided an empirical analysis which was centred on misappropriation and its relationship with trade secret sharing behaviour of firms with third parties. In the existing literature, trade secrets have mostly been studied with reference to patents. In this chapter, however, we used a novel survey data, which covered most important issues underlying misappropriation of trade secrets. This helped us to look at the relationship of trade secrets sharing and their misappropriation by various parties.

The main findings of this empirical work can be summarised as follows. We find that firms that share trade secrets information with third parties are more likely to face acts/attempts of misappropriation of their trade secrets. We also find that firms are more likely to find secrecy important for their inventive knowledge, technical information and business information if they make high usage of patents, which points towards possible synergy between patents and secrecy. This is in line with recent research on the complementary nature of patents and trade secrecy.

Now we look at the existing legal protection of trade secrets in some countries. This helps to understand the possible modifications in the existing legal system in light of the results obtained in this thesis. Note that the objective of this thesis is not to study and to provide policy recommendations to a specific country's legal system. On the contrary, the focus has been on the general features of laws governing trade secrets.

The Legal Scenario governing Trade Secrets in the USA, the UK, Germany and India

In this section, we look at some characteristics of legal systems governing trade secrets law in the USA, the UK, Germany and India. More specifically we look at three features of the legal system: whether there is separate legislation on trade secrets, what it takes to start a suit against misappropriator, and, whether misappropriation constitutes a criminal liability. A brief discussion on India is included to highlight the neglect of trade secrets in developing countries in general.

The USA

In the USA, there exists a clear definition of trade secrets, provided by the Uniform Trade Secrets Act (UTSA). Thus all information which satisfies the requirements of

UTSA may be considered to be trade secret. To commence a legal proceeding in case of trade secret misappropriation, the plaintiff must be able to show that, a) the plaintiff has interest in protecting the trade secret, b) incidence of misappropriation of such a trade secret, and, c) the defendant is behind the misappropriation. Available civil remedies include injunction for actual or threatened misappropriation, and damages (cumulative). Criminality of the misappropriation of trade secrets is subject to individual state law. California and Texas have enacted specific statutes prohibiting the theft of trade secrets, while New York has amended its larceny statutes to include trade secrets.

The UK

In the UK there is no specific legislation on the protection of trade secrets. In general trade secrets are governed by the English common law of confidence and contract law. However there are some legislations which indirectly provide rights and obligations to persons who may hold certain secrets in certain circumstances. English law does not provide a generally applicable definition of trade secrets. Freedom of Information Act (2000) provides for trade secrets as information where, "its disclosure under this Act would, or would be likely to, prejudice the commercial interests of any person (including the public authority holding it)".

Generally trade secrets are protected by confidential information under the common law provided that such information satisfies the following properties: a) Information must have the necessary quality of confidence, implying that it must not be public property or public knowledge, b) it has been "imparted in circumstances imparting an obligation of confidence" upon the recipient, and c) there must have been unauthorised "use of the information to the detriment of the party communicating it". It is important to note that classifying a document as "confidential" does not

automatically make it a trade secret, unless the document possesses necessary quality of confidence and thus creates duty of confidentiality in equity. On the other hand, an unmarked document may also be confidential information depending upon the circumstances under which it is imparted.

To commence a legal proceeding under trade secret misappropriation, it must be established that:

i) The trade secret has the quality of confidence,

ii) It has been imparted in circumstances of confidence,

iii) It has been misused.

In case of misappropriation of trade secrets, available remedies under English Law for "breach of confidence" are: a) Final injunction or interim injunction (to prevent threatened breach of confidence), b) Destruction of material containing confidential information or derived from the use of those trade secrets, c) Damages, and, d) Account of profits. Ex parte search orders are also available to preserve the documents, information and materials at risk of being destroyed in anticipation of a full civil action. A person who receives the information innocently will not be under a duty of confidentiality unless he is made aware of the confidentiality of the information. If a person independently develops the information the same as that of the trade secret, no duty of confidentiality can arise.

In the UK, there is no criminal liability *per se* in the case of trade secrets misappropriation. However limited criminal protection is achieved with a number of common law regimes and some separate legislations, like the Theft Act 1968, the Fraud Act 2006, conspiracy to defraud (under the common law), the Computer Misuse Act 1990, and, the Data Protection Act 1984.

Germany

In Germany, the law does not provide a statutory definition of trade secrets, however it is generally known to have the following characteristics: a) all information connected to the business; b) which is not public knowledge; c) which is expressively kept secret for the purpose of economic interest; and, d) the business owner needs to have a rightful commercial interest in keeping the trade secret. To commence a legal proceeding against misappropriation of trade secrets, we need the following:

i) A competent court for the appointment,

ii) Identification of the trade secret infringed,

iii) Proof of the infringement.

It is to be noted that proof of the infringement may be difficult. Case law allows claimants to file the suit by proving the necessary circumstances by relying on some legal assumption such as *prima facie* evidence. Furthermore, many cases start with a criminal prosecution, and thus the complainant generally does not have to provide all-embracing proof because it is the obligation of the prosecuting authorities to gather evidence in the preliminary proceedings. Therefore the complainant can use this evidence in civil proceedings. The following civil remedies under trade secret misappropriation can be claimed cumulatively; a) Cease and desist orders; b) Claims for injunction; c) Claims to have account of profits for the purpose of calculating damages; d) Claims for damages; and, e) Claims to hand back or destroy the protected secret information.

An interesting aspect of the German legal system is that remedies are enforceable against third parties also who may have got the trade secret in good faith. The only statutory difference is whether the secret is obtained during the employment or by industrial espionage. However the third party who obtained the trade secret in good faith can not be liable for damages, which require culpability. If the third party

does not stop using misappropriated trade secret even after being informed by the owner, the party becomes culpable. However if the same trade secret is developed independently, no action can be taken.

Trade secret misappropriation gives rise to criminal liability under German legal system. The relevant provisions are scattered over various branches of law including Act Against Unfair Competition; a) the Criminal Code; b) the Limited Liability Company Act; c) the Public Disclosure Act ; d) the Insurance Supervision Act; e) the Workplace Constitution Act; f) the Cooperative Business Association Act; g) the Transformation Act; h) the Act on the co-determination of Employees in Cross-Border Mergers; i) the Act on European Works Councils; j) the Act Transposing the Directive Regulations regarding the Involvement of Employees in SEs; k) the Public Accountants Act; and, l) the Stock Corporation Act.

India

The conditions in India are quite different from the countries described previously. The standards followed for trade secrets in India are far below as compared to that in the western countries in general (Roy 2006). India has no specific law dedicated to trade secrets, however contract law may be used in protecting trade secrets. Courts seem to have upheld protection of trade secrets on the basis of principles of equity, the common law action of breach of confidence and contractual obligation (Nomani and Rahman 2011). Courts have defined trade secrets as "formulae, technical know-how or a peculiar mode or method of business adopted by an employer which is unknown to others" (American Express Bank Ltd Vs Priya Puri, 2006).

No criminal action can be brought about for revealing confidential information. The remedies for breach of confidence includes action for an account of profits from usage of the information; action for damages and further an injunction to prevent

further use. For an action to succeed, the information should have been confidential, should have been shared under an obligation of confidence with the defendant, and the actual misuse should have been done.

Overall we observe huge differences across different countries in terms of what constitutes trade secrets and what information can be protected. On one hand, US has tough laws for protection of trade secrets and has a different legal protection particularly for trade secrets, on the other hand, India lacks any specific law relating to trade secrets. The UK and Germany also have no statutory definition of trade secrets but have stronger provisions for the protection of trade secrets. Some states in the US consider trade secrets misappropriation as a criminal offence, however the UK law does not consider trade secrets misappropriation as a criminal offence per se. Germany has relatively stronger criminal provisions under the case of misappropriation of the secret, whereas India provides simply no criminal liability against trade secrets misappropriation. Action against third parties involved in misappropriation who might have got the secret in good faith also differs greatly across the jurisdictions. Germany provides for very strong protection for action against third parties depending on particular situations under which they got the secret. Thus the overall protection of trade secrets varies significantly across various jurisdictions.

Findings of this thesis and the policy recommendations

The findings of this thesis can be used to suggest some policy recommendations to amend the legal systems governing trade secrets. For instance, the second chapter comes up with the optimal scope of trade secrets law. The focus was on the question of "how strong the protection should be", based on the market characteristics. It may be noted that the findings of the first chapter suggests that the optimal scope of the

law depends on the specific market structures in the country of interest. A thinner protection is desirable if the market is characterised by a high degree of product differentiation. We also noted that when the market competition is low, the strongest protection is desirable. Most of the results obtained in the second chapter of this thesis point toward a stronger or a weaker protection, depending on specific market conditions. Thus we require knowledge of market conditions to make more specific policy recommendation for the legal system in a particular country.

Policy makers can use various tools to make the protection of trade secrets stronger or weaker. For example, if trade secrets misappropriation leads to no criminal liability, the law is relatively weaker. Provision of damages, on top of injunctions makes protection stronger compared to a situation where no damages can be awarded. Both Germany and the US (most states) have criminal liability in case of trade secrets misappropriation. In India on the other hand, no criminal action can be brought. In the UK, trade secrets misappropriation does not lead to a criminal sanction *per se*. In the first chapter of this thesis, we looked at the ongoing policy changes in the United States and the European Union. The policymakers have recognised the need for stricter trade secrets protection, especially in the European Union.

The third chapter compared the two most used damage regimes in the case of misappropriation. The desirability of one damage regime over another was analysed. It was shown that, given the assumptions of the model, the unjust enrichment regime leads to a higher ex-post static welfare as compared to the lost profits regime. The policy makers are confronted with two contradictory objectives; protection of the innovator/trade secret owner and maximising welfare. If the prime objective of the policy makers is to protect the interests of the innovators/owners of trade secrets, then the lost profits regime is to be chosen. However, if we just look at the ex-post

welfare, the unjust enrichment is to be chosen. Which damage regime is used more in practice is again an empirical issue.

Lastly, the fourth chapter of the thesis looked at the relationship of trade secrets sharing and misappropriation. The most important insight coming from the fourth chapter is that the firms face a high probability of misappropriation when they share their trade secrets with third parties. The policymakers may want to make the information flow (in terms of sharing trade secrets) easier to speed up diffusion of knowledge. In fact, the European Commission has proposed to make misappropriation tougher in its Directive on Trade Secrets in the EU. The main objective of this new harmonised legislation is to empower trade secret owners across the European Union. Another lesson coming from the fourth chapter is that trade secrets are considered important by the firms to protect their innovative knowledge. In this way, providing better protection for trade secrets provides incentives to innovators as well. This is at the heart of law and economics analysis of trade secrets, as the law can create clear incentives for firms and have long lasting economic implications as a result. It is well documented in the existing empirical literature that trade secrets are more important to the innovators than patents and other related intellectual property rights. Therefore, providing better protection to trade secret owners also gives them incentives to spread their portfolio of intellectual property assets.

Caveats and future research extensions

This thesis has touched upon a topic that is currently going through legal restructuring in the European Union and many other parts of the world. We analysed the questions of how to structure trade secret law, what to do if misappropriation of trade secrets takes place. We also established a relationship between trade secrets sharing and its misappropriation. However, we note that the economic insights provided in

this thesis are a simplistic view of the world, which is inherent to all economic research. The policy implications need to be supported by political and legal analysis. Nonetheless, the economic analysis in this thesis provides a background for further research, both theoretical and empirical. In addition, the policy implications of this research, particularly considering the prevalence of trade secret misappropriation in the EU, are strong.

As discussed in this thesis, the economic analysis of trade secrets law is still an emerging area and provides fruitful research opportunities. Future research in this area may focus on cross-country empirical studies relating to trade secrets protection, growth in business profitability indexes and innovativeness of businesses. A relationship between trade secrets protection and macroeconomic variables such as economic growth would also enrich this area. More research on the importance of specific features of trade secrets law such as covenants not to compete and employee mobility with respect to market competition and incentives to innovate will enhance this field of law. Case studies of actual trade secrets cases and their econometric analysis would provide fresh impetus to policy analysis of trade secrets law.

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