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The Language of Trust and Reciprocity in Patent Markets

A Sociological Analysis of Property Rights on Messages Resolving Uncertainty in Exchange in Ideas

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By Eskil Ullberg[1]

"Honoring the inventor"[2] *created the basis for global trade in ideas.*

"It was quite clear that firms dealing with one another did not depend solely on the contract, but had … trust in each others actions. The economic system operated differently than if it all depended on contracts. We aught to study the relationships between firms, as a way of operating in an economic system", R. Coase, 2009[3]

Abstract

Firms exchanging technology using the patent system as a trade system (through licensing, cross-licensing, transfer, intermediaries and other mechanisms) face uncertainty that cannot be resolved by information alone; trust in each other's actions appears to be needed. Information is needed to resolve risk (a probability distribution can be constructed) but uncertainty (where a distribution *cannot* be made) requires trust in each other's *actions* to be resolved and allow for rational decisions to be made regarding price. This article explores, based on in-depth interviews with some of the most active patent licensing and patenting firms in the world, what *strategies* firms use to create such trust in each others actions that may result in reciprocation and exchange in ideas based on the patent system. In the case of patents, the rights and their economic value are particularly risky and uncertain, as new inventions in pipeline that can be held private (as trade secrets) or simply not yet invented affecting the economic value of extant patents and cooperation, creating potential for future hold-up and other non-cooperative behavior, and as the right to sue (enforce) has uncertain outcome. A distinction is also made between uncertainty in *state of the art* (new technology) and the process of managing this uncertainty using diverse (business) strategies, and treatment of risk based on *state of nature* and probabilities, hoping to expand on Arrow's (1962) and other's work, to inform a better treatment of uncertainty in economic theory.

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[2] The first known patent law (Venice, 1474). *"And should it be legislated that the works and contrivances invented by them could not be copied and made by others so that they are deprived of their honour, men of such kind would exert their minds, invent and make things that would be of no small utility and benefit to our State".* Adopted by Venice *Senate* (not a King) on March 19, 1474, as, I argue, economic policy of the then city-state. The senate could break the tradition of granting monopolies and break guilds. A similar change took place in the UK in (1623) annulling Royal monopolies. The Paris convention (1883) made patented inventions international (priority year and national treatment) and TRIPS (1994) now include 162 countries with "minimum standards", perceived by the political South to be "maximum standards", in exchange for market access ("high-tech for bananas"). Today reform is called upon in the USA, Europe, Japan, Korea and China (5 largest offices).

[3] Markets, Firms and Property Rights – A celebration of the research of Ronald Coase. Video Message from Prof. Coase, 2009: http://iep.gmu.edu/conference-markets-firms-and-property-rights-a-celebration-of-the-research-of-ronald-coase/

A systems analysis is done, where messages firms send to each other in implementing a (business) strategy to create such trust (not to hold-up, sue, etc.) are analyzed, making up a "language of trust". The analysis indicates that, across the strategies found, messages appear to create mutual and multilateral self-restraint, and take the form of informal (norm based) and formal (rule based) *contracts of self-restraint*. This is thus a sociological problem the firms appear to solve (trust not to harm), preceding the economic one (exchange), in order to sustain trade in ideas (based on the patent system). Four such (business) strategies are identified, together defining a *process* of what firms do to create trust in each other's actions. This process – that can be characterized as institution building – seems to have generality and can be found in other areas such as international relations, sports, families, and other organized cooperation.

As economic theory is based on (symmetric) information, these findings based on a sociological analysis of firm behavior, at least in the case of understanding patent markets, may also inform patent reform and policy initiatives.

Introduction

Firms exchanging technology using the patent system as a trade system (through licensing, transfer, intermediaries and other mechanisms[4]) appear to face uncertainty that cannot be resolved by information alone; trust in each others actions appears to be needed. Uncertainty comes from imprecise claims (language), enforcement procedures (courts), agreements (contracts), and most importantly, new better technology that has been created and/or patented *after* a transaction is consummated thus impossible to predict, creating hold-up and other situations, potentially impacting value. Risks come from timing of patenting, exhaustiveness of prior art searches (presumed validity), unclear ownership, etc. Information is necessary to resolve *risk* (a probability distribution can be constructed) but trust in each other's actions is needed to resolve *uncertainty* (where a distribution cannot be constructed), allowing for rational decisions to be made. Risk–resolved by information–can therefore be said to be an *economic problem* of rational decision making, whereas uncertainty–resolved by trust in each others actions–a *sociological problem*, involving what firms will *do*, i.e., their behavior given norms and rules established in the investigated patent markets. This article explores, based on in-depth interviews with some of the most patent licensing and patenting active firms in the world, the (business) strategies firms use that can be identified to resolve uncertainty by creating trust in each others actions which then allows for exchange of technical ideas based on the patent system. A systems analysis based on property rights of communication will be used to identify behavioral characteristics of firms and discuss implied efficiency of markets in patents.

Internationalization of exchange in human ideas was first impersonalized with the creation of the first patent system, in Venice in 1474, creating a competitive environment for technical ideas. Trade secrets, tightly personally held, were challenged as a strategy in favor of patents – publicly disclosed and enforced private exclusive and tradable rights on a new technology useful for economic development[5] – creating tradable private property

[4] Which may include cross licensing, securitization of patent portfolios, licensing of standards essential patents under FRAND (Fair, reasonable and non discriminatory terms), open access licensing, mandatory licensing and many more given the type of business *strategy*, industry agreements of government patenting policy used.

[5] WTO TRIPS agreement (Geneva, 1994, Article 28) defines these rights today as follows: *"1. A patent shall confer on its owner the following exclusive rights: (a) where the subject matter of a patent is a*

rights on technical ideas[6]. The policy was clearly an economic policy of trade, giving incentives to import (trade) technology invented elsewhere to the then city-state. Today *personal* exchange in ideas practically takes place across the globe through the advent of the digital economy, making new information and learning accessible, moving the exchange in ideas to a global level. An *impersonal* exchange of patented state-of-the-art technology requires yet a final step towards integration and exchange (especially North-South). This complex process of inventing, protecting, learning and exchange based on private property rights, contracts and ultimately market prices (in organized markets), still remains to be trusted by the trading parties to compete with trade secrets and other mechanisms (such as open source approaches) globally. The paper attempts to analyze the *process* of creating *trust in each other's actions*, enabling impersonal exchange in technology based on the patent system, with policy implication for a global market.

In order to analyze this process we need to separate the sociological problem (of trust) from the economic one (of risk). *Messages* that are sent between firms in order to coordinate their actions are therefore analyzed. This economic system's analysis builds and expands on the microeconomic system analysis presented by Smith (1982) and others. Economic outcomes are here decided when agents interacting with each other through institutions, arrive at an outcome by means of exchange of rules-based *messages*. The rules of the patent system (office and courts), exchange by means of (enforceable) formal and informal contracts and the economic environment are studied at the level of the messages firms send (for example: to sue, develop strategic portfolios of patents as assets, make offers, etc.) to sustain (business) strategies of trust (the sociological problem), in turn supporting exchange (the economic problem).

The study covers key aspects of uncertainty: the nature of human ideas, suitable governance structures of these rights given transaction costs under uncertainty, and residual rights of control of future rights and "common rights" as in open source.

In the economic literature much of the treatment of "uncertainty" goes back to Arrow (Arrow, 1962, 1952, p. 19) where markets in "state of nature" are used to trade risk, which appears to be built on an understanding that there exists symmetric information on which a probability distribution can be based for each state of nature. In the exchange studied here, such information *does not* exist ex ante with respect to the technology that is not yet invented but will (perhaps) be invented. The "state of *nature"* is instead state of *the art*, a *human idea*, a technical solution that can be patent protected, which cannot easily be parameterized as alternative states of nature (the states are not known and cannot be known as they are new creations that never existed before, adding to the state of the art, a sociological undertaking by people, not events by nature to which

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product, to prevent third parties not having the owner's consent from the acts of: making, using, offering for sale, selling, or importing[5] for these purposes that product; (b)where the subject matter of a patent is a process, to prevent third parties not having the owner's consent from the act of using the process, and from the acts of: using, offering for sale, selling, or importing for these purposes at least the product obtained directly by that process. 2. Patent owners shall also have the right to assign, or transfer by succession, the patent and to conclude licensing contracts."

[6] Standard conditions of patentability are: new, non obvious/having an inventive step and useful/be industrially applicable. In the US, also non-technical ideas can currently be patented, including software.

probabilities could be assigned[7]) perhaps better described as *genuinely* uncertain. This distinction between risk and uncertainty is thus here attributed to the proposition that human creativity is best understood in its own rights, not as laws of nature[8].

Williamson (1979, pp. 245-254), building on Coase (1937) and Commons (1932), in his seminal article on transaction costs focus on intermediate product-market transactions, contracts and governance structures for investment decisions under "uncertainty". A higher uncertainty would lead to a more unified governance structure (for patents this would imply coordination through hierarchy, i.e. a sequential process of invention and innovation) and lower uncertainty to market governance (coordination through markets, i.e. a simultaneous process). Here the focus is the *process* of managing genuine uncertainty, with respect to *new* patented technology, not only current technology used in products and services, i.e. investment value of what is currently offered, but of what *could be* offered, in terms of a resolution (reduction) of uncertainty through trust in each others actions. This process has states, which may be characterized by strategies used by firms. It is the strategies used, in given economic organization (hierarchy, market, other) and thus it is this process of reducing uncertainty that the paper hopes to shed light on, through studies messages.

Hart (1988) and Grossman and Hart (1986) discusses incomplete contracts (where all the states of *nature* have not been listed due to (prohibitive) transaction costs) and residual rights of control over *physical* assets, opening for a discussion on *ownership* to resolve the un-contracted states of nature through new negotiations (if the owner wished to do so). The approach then leads to resolving hold-up situations. This work on ownership has been expanded to discuss different kinds of ownerships, such as investors, managers, workers and consumer co-operatives. Here the residual rights of control, or ownership, are uncertain as *new* technology can be developed ex post contracting, creating new intellectual property *assets*, which can be contracted (viewing the patent as an asset). The key problem being potential future claims and their investment value, ex ante they were invented, a quality issue of patents to some degree (hard to specify) but also an expression of the uncertainty of value of current and future patent assets. Ownership contains both problems of risk (symmetric information on who owns what) and uncertainty (here trust in each others actions). This line of thinking also appears to be useful to apply to patent pools, zero-royalty patent licensing and open source cooperation and other mechanisms of ownership based on the patent system, building on Ostrom's (1990) research on common pool resources in particularly applied to open source software (currently a large patentable subject matter). What is possible to privately claim, and enforce in order to trade (here publicly disclosed and privately excluding rights on

[7] However, Aumann (2004) proposes a unified treatment of strategy against nature (with "objective probabilities", in the sense of Nash (1951)) and people (forming "subjective probabilities"), a proposition that appears to rely on symmetric information. Here, as pointed out, the information may be symmetric (as in patent disclosures), asymmetric (as in trade secrets) but also non-extant at time of contracting as patents represent human inventions creating a situation of uncertainty that cannot be resolved by information alone (leading to formation of a probability distribution) but perhaps only by trust in each others actions (not to hold-up, sue for infringement or otherwise harm).

[8] Since Adam Smith economist have tried to formulate principles of human behavior, inspired by the huge success of the natural sciences since at least Newton's laws of nature, but we are not there yet. See for exampled interview with V. Smith (SZENBERG AND RAMRATTAN, 2014, CHAPTER 24).

patented technology) can possibly be seen as a matter of uncertainty in ownership of (current and future) state of the art.

Coase, on the contrary, proposed in (2009) that the way we aught to look at the firm was as a *sociological* problem, not as a problem of nature with decreasing marginal returns, like in agriculture, but instead studying the relationships between firms as a way of operating in an economic system. It is this tradition that has been followed here, as firms create trust in each other's actions, exchanging new human ideas on state of the art technical solutions based on an understanding of nature (inventions not growing on trees).

The overall process can be seen as a process of firms moving from managing risk based on state of nature as a random process (as in a linear manufacturing process), to managing uncertainty and state of the art, based on a human creative process (as in a simultaneous invention and innovation process), in an economic system.

Before addressing the problem, outline of the study and observed (business) strategies, I would like to briefly stat the findings.

The key finding is that the way firms create trust in each others action in the case of patent markets is through (business) strategies built on formally and informally *contracted mutual and multi-lateral self-restraint*. The choice of strategy appears to be a direct result of the operating of the patent system (office and courts), implying strong conclusions on patent reform and "repair". The seller (or the buyer or intermediary traders) develop the contracts (and mechanisms) to act with self-restraint when new technology is developed (by either party), not to sell to a competitor (or hold-up, hold-out), or sue each other for infringements. Uncertainty in each others actions is thereby reduced – by enforcing the self-restraint (different mechanism in each business strategy) – paving the way for rational decisions to realize (sustained) gains from trade[9]. They thus exclude certain actions in these coordinated strategies, in particular avoiding hold-up, suing each other and certain other opportunistic behavior. If self-restraint is not observed (contracts are not honored) trust is enforced by moving (or the threat of moving) to strategies with less cooperation (other states of operating the economic system, ultimately changing economic structure), thus reducing the possibility to realize the higher gains from trade, making the first strategy choice unsustainable. This "negotiation for trust" is done through a set of messages together creating a "language of trust" (see Table III).

The actions observed thus go beyond simple information sharing mechanism (to resolve risk) but alter the economic structure by property rights on messages. This thus expands on, primarily Coase (1960), and puts policy squarely on access to these messages to broaden the range or firms participating in the patent market.

Four distinct strategies have been identified which can be seen as steps leading to impersonal exchange. These contract mechanisms may therefore be seen as an example of how institutions develop towards realizable and sustained exchange, having reduced uncertainty by creating trust in each others actions. The strategies firms appear to use are:

[9] However, there is always an alternative to patenting, keeping your ideas to a single hierarchy as trade secrets, not sharing the state of the art with the world through patent disclosures, but then one remains exposed to reverse engineering, transfer through former employees, industrial espionage etc, of products and services.

1) "Staying clear" of each other's patented technology using a MAD (Mutually Assured Destruction) strategy to enforce lack of self-restraint in using the other's rights. Patent enforcement costs (administrative or court) will outstrip gains from infringing. Technology use is then "cleared" in the product and service markets, not in the technology market.
2) "Strategic alignment", which gives both parties access to each others new patented technology during a pre-defined period (3-5 years) by a so called capture period contract. It is thus not possible to sue (or otherwise harm), since all extant and *future* patented technology is licensed (or cross-licensed) up-front and openness of information is institutionalized (periodic audits).
3) "Marginal transactions", where parts of patent portfolios, standards patents or individual patents–often well established technology in use, implying known value–is licensed and cross-licensed. This is enforced, when possible, in patent courts. The trust is here completely in the patent office and courts (validity).
4) "Systemic abuse", where firms assert (often low value) patents for infringement to extract rents in face of high court costs for the defendant. This is enforced by (larger firms) through an all-out attack on the litigants (thus often lousy) patents, forcing a *value* judgment by courts, thus destroying the business model of these firms (this includes an asymmetric information problems as well). Trust is thus here created by giving incentives to sell valuable technology or be run out of business[10].

In all strategies self-restraint appears to be the resulting behavior of the parties, supporting sustained exchange, enforced by destroying or eliminating gains from exchange through a less cooperative strategy if parties behave opportunistically[11]. The self-restraint is thus created through contracts and enforced with help of institutions of the patent system and civil law system[12]. This can be seen as an emerging market in patented technology on its way to institutionalization. The property rights that can be enforced thus structure the economic system[13] in steps.

In addition to self-restraint the economic concept of "search costs"–making sure there is no infringement–mattered considerably for firms in their choice of strategy. High search costs resulted in situations where staying clear (1) or systemic abuse (4) strategy were chosen, whereas low search costs appeared important for strategic alignment (2) and marginal contract (3) strategies to be chosen. This is a risk problem and further

[10] There is a rather diverse discussion on "patent trolls", Non Producing Entities and Patent Enforcement Agencies, etc., since some time. Characteristic in these discussions is the rare discussion on the value of intermediaries in creating a market, where prices reflect value. A hierarchical view of invention and innovation appear to be the normative assumption. Since 1474, 1623, 1834, 1883 and 1994 patents the "normative patent law" has been exclusive use AND transfer and licensing (creating a market in ideas). It is maybe time for economist to think about patents as excluding rights that are tradable, changing the economic structure towards specialization, where promises of gains can be achieved.

[11] In a general sense (covering a range of informal and formal contracts) this finding is in support of Smith (2004, p. 69): "If monitored and externally enforced rights can never cover every margin of decision, then - contrary to the notion that markets depend on selfishness - opportunism in all relational contracting and exchange across time is a cost, not a benefit, in achieving long-term value from trade."

[12] Patent infringements are a civil offence not a criminal offense.

[13] The main message of North (1981): It was not a change in activity that created the first economic revolution (agriculture) but a change in property rights which in turn shifted the incentives to invest in agriculture.

institutional development was called upon by several firms such as a registry of ownership of patents (which does not exist in any updated or transparent form[14]) and "quality patents" (high presumed validity).

The strategies indicate that a contract also has to include provisions for self-restraint and enforcement mechanisms have to be accessible for all firms engaging in inventive activity, in order to move from a (1), and (4) "litigation" strategies to a (2) and (3) "negotiation" strategies allowing for gains from exchange patent markets higher growth in technology and potentially higher economic growth.

These findings create policy input on a number of areas such as contracts (as a first step towards institutional development), patent quality and publicly listed ownership, and enforcement practices. A policy proposal is discussed to reduce cost of using the patent system as an exchange system to the individual (or small team) inventor(s) level. Such a policy would allow exchange in human ideas across the economic system at an unprecedented level. This thus has implications for North-South exchange in technology, addressing economic inequality issues as well, through trade.

The strategies appear also to have general applicability beyond patent markets and anecdotal examples from international policy and other fields are elaborated on for a general research agenda.

1. A Sociological Problem

(This section could be moved to a separate paper)

To analyze the strategies of firms I will first give some background on the patent system as a *trade* system and its sociological and economic dimensions, in particular a distinction between creation and discovery.

The patent system made *exchange* in technical ideas (technology) possible in a market with prices, by giving the holder *excluding rights* (to prevent use by others and to assign, transfer and license the patent by mutual consent) in *exchange for* public disclosure (teaching) of the invention to the world[15]. In this way the patent system makes higher growth in economically useful technology possible through (often dynamic) cooperation between specialized inventor firms, innovators and nations, motivated by gains from exchange in technical ideas, in a highly competitive manner, driven by

[14] As this is written a bill is proposed in the US to deal with this problem. However, it is unclear if the bill is written in the spirit of trade and exchange. There are a number of private firms developing databases in with "cleaned" data today.

[15] Under the WTO agreement on Trade-related aspects of Intellectual Property Rights (TRIPS) there are 7 rights. A patent is granted for mostly technical inventions that are new (no prior art exists), have an inventive step/are non-obvious and an industrial applicability/useful. Most patent systems follow this principle of temporal exclusive rights in exchange for public disclosure. In fact this was the principle introduced in the firs patent system in Venice in 1474 in an apparent attempt to *import*, i.e. trade, productivity enhancing inventions useful for the early manufacture economy. A 7 year exclusive right was issued in exchange for disclosure. The explicit underlying principle in the law was 'honoring the inventor'. This principle appears to have been lost in economic analysis and much of the discussion on patents. This is most notably commented by Plant (1934, p. 51) "Expedients such as licenses of rights, nevertheless, cannot repair the *lack of theoretical principle* behind the whole patent system." (Italics added). However, viewing the patent system as a *trade* system introduces the most fundamental economic principle, that of exchange.

demand for new technology. This *producer market* in patent protected technology is input to today's global manufacturing and service system. Product and service innovators are the source of such demand, in turn motivated by gains in those markets. The distinction between invention and innovation markets is important for a better understanding of policies that may create a more dynamic economic system today, when explicit trade in technical ideas is taken into account in the economic growth process, driven by a goal of a more efficient (and sustainable) economic system. The patent system of 1474 to "honor the inventor" can therefore be seen as an economic policy motivated by trade in ideas, institutionalizing self-restraint (not stealing from but honoring the inventor's investments in new technical solutions) through somewhat enforceable property rights.

Such exchange is both risky (asymmetric information) and uncertain (as there is no way one can encompass what solutions every human will creatively come up with in the future). All exchange has these characteristics but here the "product" may be less valuable, given new inventions – human creations – that are impossible to predict with certainty (some would say "disruptive"). A sort of a gamble (compare Bernoulli (1738)).

One can here differentiate between human discovery and human creation: in the first instance what already exists is discovered (a resource, information, or law of nature) and in the second something that does not exist naturally is created by a human creative act of problem solving and reduced to practice. However, in the medieval Europe the Latin "invenire" (invention) was the word used for discovery of for example an iron ore. The meaning of "invenire" was accidental discovery (such as in a random process) where as "ars" (art) was used to connote derived technological know-how (such as in a purpose driven process)[16]. "Ars" would thus be the process to extract the iron, like pumps to pump out the water. Thus, an inventor would be honored for new inventions that surpassed the state of the art (a new solution was "discovered"). The difference is that the iron ore was there all the time where as the pump was a solution created by a human idea. Similarly, institutions are human creations (even if we only over time discover which rules work and which don't), of which the patent system thus is one (economically important) example. The creative process is thus more of an individual and sociological process (with claims on intellectual property assets) whereas discovery more of an economic one (with claims to a physical asset). The distinction between the human idea on using nature, and nature it self, runs deep in the patent system from the time it was first construed, making the distinction of state of the art as a sociological (invention) process and state of nature a random (discovery) process quite meaningful. This discussion on discovery and creativity needs to be further elaborated on elsewhere but is mentioned here simply to give some historic perspective of the economic thought related to inventions.

Firms often choose to keep inventions as trade secrets using them on their own, timing patenting or racing to patents depending on market dynamics. Firms may hide what is in pipeline for a trading partner to reveal it later (hold-up), or sell to a potential competitor (hold-up/hold-out), or someone who can become a competitor, changing the potential value for the buyer. Or firms may simply be withholding ideas for cost reasons, timing of investments, depreciation of assets, etc. The value is hard to estimate for most

[16] See (Kaufer, 1989, p. 2) for a discussion on the origins of the word invention and patent.

technologies, or combination of technologies, making choices between technologies difficult[17].

An inventor firm typically does not reveal everything invented, has technology in pipeline, thus may keep more valuable technology for later, can hardly know everything that is in the heads of all employees, or what further ameliorations or related inventions may be made in the near or distant future. These characteristics and others of inventing, here characterized as uncertainties, appear to make mechanisms of exchange of ideas more difficult than for products and services.

By disclosing the inventions, the state-of-the-art is revealed and future inventions then build on technology closer to the state-of-the-art, thus *increasing* competition in development of technical ideas. By granting *tradable* rights on these state-of-the-art ideas, more exchange in ideas can take place between actors, each benefitting from the specialized knowledge of the other.

Fundamentally, these characteristics of exchange in technology between firms, based on the patent system, make it *genuinely uncertain*. In markets, agents have to choose rationally between alternatives based on price. (See for example (Coase, 1990, p. 80)). But how can you choose rationally when the value (and thus price) is uncertain (no distribution can be assessed) and the actions of the trading parties are uncertain (not known to anyone)?

The patent system therefore appears to create a particular economic structure (organization) when coordination of inventive activities moves from *within* a firm (hierarchy) to a *between* firms in a market with prices. A well functioning of this coordination would thus enable growth in technology, the basis of economic development. Today the trade in ideas, using the patent system to license technology, is estimated to the order of a trillion US dollars or more. If one would include cross-licensing, FRAND agreements on standards the value of such exchange in technology based on the patent system would probably be many times higher.

To deal with situations under *risk*, one clearly needs *information*, and preferably symmetric information to have markets with rational prices. However, under *uncertainty*, one needs *trust* in each others actions, to make rational decisions. The first problem clearly falls into the category of economics where as the latter is a sociological one. Exchange in ideas using the patent system thus requires the firms to solve the trust problem prior to exchange.

To investigate what firms *do*–and *why* they do it–to actually overcome this uncertainty, and thus create trust in each other's actions, in this global and documented trade, has been the purpose of this project.

2. The Study

The study was organized as a set of in-depth interviews with the heads of, and sometimes teams of, patent policy and licensing departments of mainly global firms exchanging

[17] About 2% of all patents are used in products and services (Source: EPO). This does not mean that 98% are economically useless. They are used as a strategy to exclude competition to get "too close" to a "core" technology (creating a larger technology area of claims), a pipeline of technology to be used later, trade (licensing, cross-licensing) or other strategies companies use or can invent.

rights on *patent protected* technology. 13 firms of which 10 were among the major patent licensing and patenting active firms in the world, participated in the study (all under request of anonymity)[18]. One firm declined but gave such interesting reasons they are listed among the 14 firms interviewed. Most representatives where senior patent licensing professionals, having spent most of their career in the field, sometimes 20-30 years, and with a range of companies. Since there are alternative mechanisms to patents for sharing ideas, one "open source" network was interviewed (who also have patents). However, the focus of the study was firms using patents as the basis for *exchange*.

The selection was made with the criteria of: (i) patent licensing (trading) active firms (both producing firms and non-producing, intermediary trading, firms), (ii) industries where licensing is particularly active; industries with *high interoperability*, or component based industries and, (iii) preferably large firms (which trade with both large and small firms and therefore have experience in the most diverse range of strategies. Studying the large firms would thereby reveal strategies used together with small firms as well as large firms). Industries with low interoperability were approached (oil), but there was no interest to participate in the study as "they did not share technology" as one firm put it, which appears to be an interesting finding in itself[19]. The importance was to investigate the *broadest possible set of strategies*, and large firms typically face those challenges in all fields, not only in patent licensing. A specialized intermediary firm was also included as was an "open source" firm, to capture these roles better. Some firms were new to this exchange whereas others were well seasoned. This was done to capture as much of the dynamics of the global patent licensing system as possible. By this selection, the hope was that *basic* strategies could be discovered and documented, useful for sustained business models, not just special one-off cases, but hopefully the more general cases. This generality would then be used to formulate testable hypothesis of the behavioral properties of creating trust in each other's actions, suitable for further analysis. Table I lists the firms by number in the study, industry, order of magnitude of patent portfolio and market presence.

[18] Names of firms participating have consequently been removed. However, identification by number is used in tables, etc, to relate a firm to a certain industry, and other possibly useful characteristics to relate the observed *behavior* to a unique entity.

[19] It is now a well-known fact that the oil industry does not share safety standards or technology internationally possibly to a lower extent than within other industries, which became clear during the BP/Halliburton catastrophe. After the disaster, there was some increase in security cooperation forced on the companies by governments, if I am correctly informed (http://www.ogp.org.uk/global-insight/international-standards). These industries appear to be similar to the telecom industries before de-regulation. There was a gentlemen's agreement that technology was developed for the local operators. After deregulation, a global competition in technology started.

Table I. Firms interviewed

	Short Case Study				Primary business		
Firm ID	Region	Technology (Industry with high interoperability)	Patent portfolio	Patenting	Licensing	Producing	Services
1	US	IT	> 10,000	x	x	x	x
2	US	Software	> 10,000	x	x		x
3	EU	Software	> 1000	x			x
8	US	Software	> 10,000	x	x	x	
4	EU	Telecom	> 10,000	x	x		
10	EU	Telecom	> 10,000	x		x	
7	US	Telecom & IP	> 10,000	x	x	x	
5	JP	Consumer Electronics	> 10,000	x		x	
9	TW	Consumer Electronics	> 1000	x		x	
6	US	IP	> 10,000	x	x		
12	US	IP	> 10,000		x		
13	US	IP	> 10,000	x	x		
14	US	IP	> 1000		x		
11	EU	Oil (shorter discussion)	> 1000	x		x	

The interviews where conducted with as open questions as possible, to allow the firms to express *their* strategies (not wanting to impose a rationality of our own). Two basic questions were asked: *What* do you *do* when licensing patents? (process, contracts used, technical issues, policies, determination of fees and fee structure, etc); and, *Why* do you license patents the way you do? (strategic considerations, business model, industry, dynamics, etc). A third question was directed towards the role of *trust* in licensing and how they went about creating that trust in each others actions (which was asked as a hypothesis).

Most respondents gave very elaborate answers, resulting in page after page of interview material, as they laid out how they approached the licensing issues, their business processes and the role of trust, if any. After a number of interviews, common themes developed (were discovered) and additional questions were asked, testing some hypotheses. These questions were in particular related to practices on types of contracts used and contract changes over time (institutional learning on contract development), procedures to secure non-infringement (search costs), the view of contracts as "insurance" against loss of market access (see (Ullberg, 2012)) and being sued, and other similar institutional, contract, and management - governance issues.

There were also, towards the end when most data had been collected, seemingly conflicting visions about where exchange in technology *is* going or *aught* to be going. This was in particular the case between "open source" approaches to cooperation and patent rights approaches, both however using patent rights, but in quite different business models. As there is much research on open source schemes (for example work by Schweik and English (2012) based on Ostrom (2010) and (1990)), the main focus was how that "open source" strategy interacts with strategies of cooperation *with* property rights.

Some firms were interviewed once over the phone and others with sometimes several follow-up interviews and on site visit for in depth discussions with the whole team of IP professionals. In total about 40 interviews with 13 firms (and 1 decline) where

carried out representing different expertise as the firms had seen fit to organize their activities. The people interviewed worked with patenting, patent licensing contracts, financial valuation of portfolios, royalty audits, representing open source movements, organizational learning, litigation, acquisitions, patent sales, etc. representing a very broad set of skills one would expect in global exchange in ideas based on patents.

As firms required anonymity and that data be presented in summary form, information that could reveal the identity of a firm is intentionally general. Specific comments are used in the text to represent views, in a non-firm specific language.

3. Business models supported by strategies and messages

3.1 Business models

The study recognizes that there are different business models used by firms and economic organization with respect to *patented technology*. The business models–the way firms operate as they compete for clients, structure their transactions, and earn their profit–are used to characterize the economic environment of the firms investigated. Different models are simultaneously used, by different or the same firms and represent fundamental (business) strategic choices of firms[20]. The models go beyond traditional economic analysis of hierarchy or market coordination of activities. Four business models are used to describe the environment for the purpose of this investigation.

1. Hierarchies (vertically integrated with respect to invention and innovation)
2. Networks (voluntary organizational cooperation between firms, including joint-ventures, loosely couples networks, open source networks (software))
3. Transactions (cooperation through tradable contracts)
4. Rent seeking (non-incentive compatible mechanisms created and *de facto* endorsed by court enforcement practices)

Firms operating in a *hierarchy* are firms that both invent new technology and innovate new products and services within the same hierarchy (firm). This is the analysis most economists use such as Schumpeter (1942, 1934), and the approach in Arrow (1962). This represents a *personal* exchange mechanism between people within departments of a single firm hierarchy. What is exchanged *between* firms in this model, is information on the state of the art, shared through the patented technology and through the patent disclosures. However, this creates a competition in technology closer to the state of the art than without patenting as some technology that would have been trade secrets is disclosed and patented.

Firms operating in a *network* are similar to the hierarchy. Here it is common to share technology, know-how including patented technology. Patent pools are created to

[20] For a discussion of business models and risk see (Ullberg et al., 2002), where the choice of business model is based on how management of risk and uncertainty has developed in the economic system during the last 100-150 years.

manage common patent holdings and other mechanisms like royalty free licensing. The network aims at creating a common product or service with common, shared, resources and can thus be seen as a loosely held firm (creating access to "common" assets). Therefore the hierarchy and networks are here treated as hierarchy as the coordination is still very personal and long-term.

Firms operating in a *market* are firms that contract patents through transfer or licensing, cross-licensing agreements. These could be for all patents in a portfolio, some selection of patents, limited to a certain field of use (products, services) or geography (markets), made possible by specific claims and validation states. These contracts are more impersonal in nature, and these agreements can be strategic or for marginal gains.

The fourth category is firms that, as a business model, extract rents by *systematically abusing* the patent and court systems. These are firms, who threaten to sue on the basis of possible infringement of patents, but the economic value of the patent has typically low merits – or even validity, but the court costs are prohibitive to clear these allegations. They are able to extract rents by forcing on patent licensing agreements, even if the patents are economically poor but it is cheaper, and most importantly speedier, to accept a license than go to court. This abuse is thus motivated by rules that give incentives created by the patent systems and not focused on economic value. Such rules are not incentive compatible with some social measure like Pareto optimality.

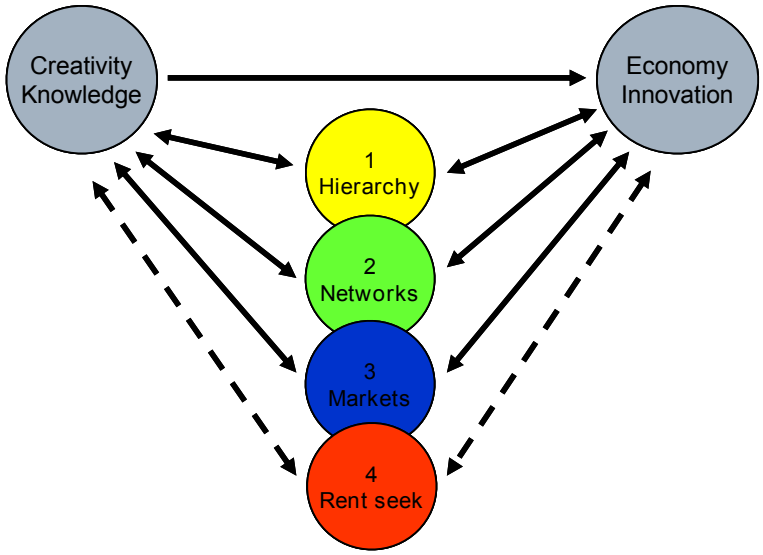

Fig 1. Business models used to coordinate invention and innovation

In the following analysis we will now use the presented economic systems approach, business models (economic structure) and their different (observed) strategies to understand what firms do to create trust in each other's actions through formal (and informal) messages.

3.2 Message analysis

To analyze the interaction between firms exchanging technology using the patent system, the microeconomic system analysis described by Smith (1982, pp. 924-927) and others is used. Agents here interact through language made up of agent specific (formal) messages to produce economic outcomes. Here the method is expanded to include messages that aim at creating trust in each others actions, to capture the process by which agents arrive at reducing uncertainty, making exchange (messages) possible. The agents' formal or informal *property rights in communication* (what messages can be sent – and not sent – by an individual agent) are then defined from the observations, structuring a language. The way firms have arrived at the messages and strategies are considered an institutional learning process. We are now ready to summarize the strategies and messages.

4. The Language of Trust and Reciprocity

The interviewed companies and their trading partners fall into one or all of the business models: hierarchy, networks, transactions or rent seeking (the last only as trading partners to interviewed firms). What is characteristic is that firms in more competitive industries tend to cooperate more on technology, thus moving away from hierarchy (and networks) towards a market approach[21]. As the selected industries have high interoperability, exchange in technology based on patents would be expected but still their strategies differ considerably, even within the same product and service industry. Firms clearly choose their competitive strategy to promote value for customers and other stakeholders, not necessarily resulting in socially preferably outcomes[22].

The technology exchange strategies based on the patent system appears integrated in the firms' overall corporate strategies, but to a varied degrees. The competence on managing intellectual property rights (IP) is entering the executive decision making and board rooms, and many firms have turned trade in IP into a business or profit center. However, the tools used (databases, contracts, procedures) are mostly in-house creations, and some use expert firms. Competences come nearly exclusively from the legal side of patenting and, in some (pioneering) cases also from the financial or management consulting industry, or consumer (market) surveys in attempts to provide an economic basis to value patent portfolios useful in negotiations.

The firms organizing their business along the four business models – or combinations thereof – can be summarized in four identified and distinct strategies to create trust in

[21] In the industry, which declined to participate in the study, the oil industry, almost no technical cooperation between companies occurred, and instead they develop their own technology in a hierarchy structure. This used to be the case for most industries 100 years ago (invention and innovation in the same firm), like in most economic analysis, but during the last century industry after industry have changed to a more cooperative mode – starting with networks – using the patent system at the heart of their coordinating mechanism.

[22] This is thus the daunting task of economic system development: to create incentive compatible rules. This must require some external input to the economic system.

each other's actions. These four strategies used by the patent licensing active firms in the study are:

1. *Staying clear* (of each others core technology areas)
2. *Strategic alignment* (cooperating transparently for a 3-5 year period)
3. *Marginal transactions* (trading high value patents as needed)
4. *Systemic abuse* (asserting low value patents with threat of high court cost)

Some initial observations will be made in section 4.1, and the strategies will be explained in section 4.2. The relation between the choices of business models and strategies is shown in Table II. Institutional development is needed to enable business strategies that are more cooperative. The table shows also the strength of hierarchies, as they basically operate across the board, and thus have fall back positions if more cooperative models do not work. The (x) notation of systemic abuse means that this is not the core strategy but reportedly takes place as part of these models as well. As we will see in the next sections trust would be expected to be created by the use of different *mechanisms*. The firms thus implement their strategy–or create their strategy space–in one of the business models. Large firms tend, quite naturally, to choose models with greater strategy space.

Table II: Business models and strategy to create trust in each others actions

	Strategy			
Business Model	1. Staying clear	2. Strategic alignment	3. Marginal transactions	4. Systemic abuse
Hierarchy	x	x	x	(x)
Network		x	x	(x)
Transactions			x	(x)
Rent Seeking				x

4.1 Some initial observations on dynamics

These observations are probably quite obvious to any practitioner in the field, but documented here to give some short facts to the discussion on information and trust.

4.1.1 Change of international property rights regime on ideas changed business models

The change in business model was given as a primary reason for the expansion of patent licensing during the last 100 years. From the mid 19th century firms have moved from being motivated by *exclusion* of others, i.e. a hierarchy approach to invention and innovation, to be motivated by *exchange* through diverse manners of licensing, potentially benefitting from the best technology globally. This change may be attributed to the simultaneous decline of (royal/state) monopoly privileges and rise of merit based intellectual property rights.

The specialization between invention and innovation has opened a market in inventions, enabled by the global expansion of the patent system property right regime[23], leading to this *structural* change in the economic system. This causality is key to the proposed thesis on the patent system as a *trade system* studied and tested in my (2012) book. This observation of change in business model may thus be that the patent system contributed to such a structural change, by a change of property rights regime, shifting the incentives to invest in technology to a more aggressive R&D policy as competition increased, thus slowly shifting the structure to coordination through markets, not hierarchy. The strategy then shifts, by necessity, towards creating trust in each others actions as firms exchange rights to use technology using the patent system. A market is established, creating need for intermediaries as "market makers".

4.1.2. Institutionalized learning in non-standard contracts - a sociological process

An observation on such cooperation through exchange was that almost all contracts used were *non-standard* contracts. The contracts used had developed over time to fix problems in the past (institutional learning). The more successful firms commented that the most important factor of success (i.e. profit) in patent licensing lies in institutionalizing a *learning process* of contract writing, getting feedback from the transactions, figure out a solution to the problems encountered and then systematically put that solution in the language of the contract to be used in the next transaction. This suggests that the institutional, or at least contractual, development is a process driven not only by legal or economic rationale, but by a *sociological* process, taking into account what trading firms actually do: based on experience of behavioral properties of contract clauses. This observation has similarities with the incomplete contract theory of Hart and Moore (1988) and (Hart, 1988). The companies having this internal process all had a much broader and nuanced approach of contracting in their industry. All contracts were strictly private information; however one firm shared a contract as an example.

4.1.3. Timing of licensing

Firms being a licensor typically also try to negotiate a license when the uncertainty of the value of the technology is the highest, i.e. as early on as possible after the invention process, which would keep the *prices* down. The hope being that innovations using the technology would be possibly more profitable, if the technology was adapted and successful.

4.1.4. Adoption of technology through a market

A fundamental concern of the top patenting and patent licensing companies was that the technology licensed aught to be adopted for long-term product or services use.

[23] The patent system expanded rapidly internationally during the 19th century, after much discussion, culminating with the Paris convention in 1883, which was the first international patent convention. It was based on two principles: priority year and national treatment. These principles are still the guiding principles for patent cooperation in the world and the Paris convention is the only "international" patent system. Since 1994, with the TRIPS agreement by WTO, an almost global agenda has been attempted.

The agreements also have to be designed in such a way that firms are willing to pay for it, the alternative is another technology or own technology. This clearly bears witness of a competitive market in patented technology. The "temporary monopoly on product" treatment of the patent system by economic theory therefore appears to be lacking this fundamental competitive use of patents[24].

Here several of the most experienced firms advocate for a strategy of *industry adoption* of a technology, rather than pricing on the margin in one relation, the immediate value for the licensor. The licensor can thus be seen as *investing* in the licensee (given the cost schedule), in order for them to adopt a technology that may be profitable in the product/services developed for the *licensees* markets (there is a risk sharing element). Such a problem may be considered a principal-agent problem. However, the collaboration aims to get adoption for a certain technology, which may become profitable for the licensor (the principal) if their technology would be used by the licensee (the agent), and in that case would generate a royalty stream down the road. There is thus collaboration between the inventor and innovator of specialized knowledge.

Here we see that the competitive equilibrium according to Muth does not hold, at least not on the margin, nor Nash, which calls for information symmetry, but there is another solution concept expressed here where self-restraint plays a key role.

This observation is the same as to say that they show a measure of *self-restraint* in the negotiation, regarding access and price of the patented technology, in order to allow for an exchange to take place where gains could be *realizable*. This action was observed among most patent active companies as a *policy*, thus indicating a realizable and *sustainable* approach, a business of exchange[25].

4.1.5 No trust – in the positive personal or impersonal sense

All firms expressed clearly that they did *not* place *any* personal, institutional or calculative[26] trust in each other's actions, in the sense that firms would do what was beneficial for the other firm out of some good will. They did not expose themselves to this "pure trust", in the sense that they counted on that the other firm would act in their own interest (or they would act in the other firm's interest). However, the key finding was that they *do* put trust in each others actions *not* to do certain harm such as sue, hold-up, act opportunistic, etc.

[24] This is a point to which I wish to develop further elsewhere. We are here talking about exchange in new, unique and industrially useful technology, not the products or services in which the technology may or may not be uses later on. This is thus a *producer* market in technical ideas, not a consumer market in products and services. Economic theory appears to treat the patent as a product or service commodity, but what is protected is a technology possibly useful in multiple products and services.

[25] It is well known that licensing is a trillion dollar business today, but the point here is to begin to frame the observations as input to economic theory. As it appears at this stage, there is no concept that includes how firms manage this uncertainty. That is the reason why some of the process is described at some schematic level.

[26] Williamson (1993) concludes that the word "trust" aught to be used only in "personal trust". Institutional trust is really calculative trust. However, here trust is used in the sense of trust in each others actions, which can be both positive (that firms will reciprocate out of good will) or negatively (that firms will not do certain harmful actions).

4.2 The four strategies explained

The four strategies will now be explained emphasizing the observed common theme of *informally of formally contracted mutual and multilateral self-restraint* and the messages sent with apparent purpose to create trust in each others actions.

1. Staying clear means that firms engaging in both inventive and innovating activities in the same hierarchy, stayed clear of each others' core competitive technology areas (in terms of patented technology). Firms thus specialize in key technology areas, creating a certain exclusive technology areas which they mastered better than others, through patent portfolio buildups. They create trust in each others actions – not to come too close to the other firms core technology areas – by using the patent system to protect proprietary technology areas (not simply single patents, which typically cover smaller areas) and by trying to invalidate competitors' patents through administrative and legal procedures that are "too close", making the point that it will be expensive to get too close to their technology area. The *message* sent is thus through the patent system procedures by often being extremely active and "on top of" any technology (application or patent) that may be perceived as "too close". (To gain an upper hand on information on competitor's possible direction of future technology, they frequently attend technology meetings, conferences etc. to search for possible research that formulates technical *problems* which indicate future areas of patenting.)

Also, as patents are hard to clearly specify, a large number of patents *increase* uncertainty in the rationale of getting too close, as a litigant may be countersued by the defendant[27]. Such response is mutual, resulting in very large patent portfolios as a *patenting* strategy, with many opportunities for suing *each other*, creating an economic environment where no-one can really come out better off if suing. This appears to be similar to a mutually assured destruction (MAD) strategy, and in fact the firms talked about this strategy using those words. This policy thus makes parties staying clear of each others' key technology fields, and one creates a trust in each others *actions* that they will not come close, not sue, not harm but "stay clear".

The mechanism of creating trust in each others actions, that they will not be sued or infringed, etc, is thus achieved by *mutually enforceable self-restraint*. Parties trust that they will not be systematically infringed, thus can make rational decisions (choices) on investing in research and development resulting in new patentable inventions and product and service innovation, by relying on their mutual retaliatory capacity.

The patent system plays a key role in coordinating these activities both through disclosure (everyone knows which fields the others find important), which is used to signal but also increase risk and uncertainty by confusing ("hiding" information of strategic initiatives using patent classification system innovatively, and other mechanisms, leading to deferred publication, where possible, hiding *ownership* where possible.).

No formal contracts are made. Instead, the value of the in-house patented technology is essentially cleared in the product and service markets where their respective patents are used. Strategies like corona patents (patenting possible product and

[27] Famous cases involve many global firms in particular in non-component based industries, and where competition is limited.

process ameliorations around a core technology) attempt to end such a competitive position once the core patents run out.

Market access for products and services are attempted to be assured by making sure no-one comes too close to the competitive technology.

Maximizing *uncertainty* in what is being invented and patented and maximizing *certainty* in patented core technology (creating assets)–"what we want are patents like tigers!"–is the solution in this strategy. Such strategy can only be used by very large firms, and even they cannot afford a "patent everything policy" having a patent department budget, limiting the value of a strategy of creating uncertainty in favor of certainty. These firms repeatedly call for quality patents, not volume patents (which thus reduces the overall cost of patenting).

Trust is thus created by mutually assured destruction (costly legal battles) giving incentives to stay clear, maximizing uncertainty of actual patent portfolio technology protection which increases the probability that firms do infringe each other, and that some of the patents actually "bite". Large patent portfolios with these characteristics allow the parties to make rational decisions on investments in R&D, based on the patent system's signaling and excluding properties. Such "giants" put almost everyone else under their shadow of patent protection, increasing the uncertainty from gains in exchange for non-equal size parties, like SMEs, or new entrants (initially too small IP portfolios to pursue this strategy[28]).

2. Strategically aligned firms engage in cross licensing agreements for a period of time, typically 3-5 years, based on whole or parts of large patent portfolios. These contracts often have a *capture period* option, which means that all *new* patented technology during the duration of the contract will also be included (captured) in the agreement. New patented technology will not be withheld, nor will information be withheld about what is in pipeline, as they have cleared all extant *and future* patented technology in the contract, and expressed sharing of information. They are thus exchanging everything (or parts of everything or for a particular product and services market) with each other in order to have access to future technology, with much lowered uncertainty. This is almost the opposite strategy of "staying clear". These agreements can be limited to specified products or services, creating a "strategic alignment" in patented technology (not products and services!) between the firms during the period. The contracts can end without possibility to extend them, or have clauses of renegotiation of price to extend the access to technology, so called "guillotine contracts". They can also be valid for the life of the patent, thus guaranteeing that the technology can be used in extant products and services. These contracts result in net payments when parties are unequal in perceived patent portfolio strength.

Trust in each others action – that parties will not sue, harm, etc. – on extant or future patented technology is thus assured by clearing extant patents with cross-licensing and adding this special formal contract which takes away the possibility to sue for *future* patented technology. There is thus a mutual (or multi-lateral) contracted *self-restraint* on

[28] A publicly reported example here is of course Google's repeated attempts to buy patents to defend the open Android system. Public cases like the Rockstar consortium are a cooperative response from the telecom and software industry to this new business model of advertising which could price out the telecom services and software. The message was clear: Stay clear of our business model!

each others actions not to behave opportunistically with new patented technology. Neither party can "renegotiate" prices or have competitive bidding (hold-up) on new patents.

The *messages* sent in this process is a formal one "not to sue for new patented technology", creates trust in each others actions to that rational investment decisions can be made in R&D and product and service innovations. This strategy, to be effective, can be pursued by firms with large, but not necessarily very large portfolios, which could "clear" technology useful for a strategic period. The solution to trust is thus negotiated by a different mechanism, enforceable contracts, rather than enforceable property rights. (Trade moves from a product/services market to an *asset market* with personal/impersonal contracts, a market based on the patent rights).

If a breach of trust is done, with respect to use of patented technology in products or services not contracted (fields of use, or markets), or not reporting sales properly, annulment of contract, etc. there will not likely be any renewal or further business the next period thus moving to a "stay clear" strategy. That strategy may not be preferred.

3. Marginal transaction firms engage in more or less transactions on *high value* patents, often in the form of smaller or larger portfolios. The competitive value of technology is thus much more known in these cases, or believed to possibly have value for a direct application in innovative products and services. The purpose of this licensing is thus more directly related to an investment in innovations. These contracts are thus made to clear extant patented technology in new (or current) innovations. The contracts can be for the life of a patent or a specific time. Straight forwards licensing, cross licensing or other forms like standards licensing are different versions of these transactions. There is little or no strategic alignment here, with capture periods, and intermediary traders (who do not patent) can therefore be a source of patents in this exchange. However, information asymmetry plays an important role as truth revelation about holdings is important in pricing bundles of patents. Some of these contracts are highly standardized "tear off" license contracts that can be bought on the internet, for example regarding usage of some standards. A broad range of types of contracts are found but the common theme is that they all relate to extant patented technology with proven or anticipated value.

Trust in each others actions is here created by clearing specific patents listed in the contract for certain products and services and by the existence of formal and competent patent courts that penalize infringers based on value and proportionality. Clarity of ownership is a key in this strategy. The trust is thus much more impersonal than in the other examples.

The *messages* sent are willingness to engage in contracts and filing law suits, if infringements are suspected outside of the contracted areas. If a breach of trust is made, then long court battles may be started, with the purpose of enforcing the patents. Parties thus restrain from infringing by a policy of honoring the inventor resulting in marginal transactions. These may result in a "staying clear" strategy if trust is breached but more commonly a license agreement often including penalty for infringement use at a multiple of the "typical" royalty rates as a penalty or other mechanisms to deterring infringements.

4. Systemic abuse firms engage in rent seeking using the patent courts, often trying to assert *low value* patents. These firms can be considered inventors, intermediary traders or

innovators, and they seek out, often larger firms in large volume products and services markets, and assert their low value patents against a likely infringement. As court procedures are very costly, around $1-2m/case, these firms then propose to settle out of court for a smaller sum against a license to use the technology. Since this is a cheaper way to clear the potential infringement, many firms settle. This is thus "Russian mafia like methods, paying protection money" as one large firm called it. However, recently this approach is also used against smaller businesses potentially infringing low value or patents that might be invalidated in a reexamination. The business model thus relies on high court costs, in particularly in the USA, where asymmetric costs can be imposed on the defendant by the so called *discovery* procedure, by which the defendant have to reveal private information to the courts, like emails, documents, etc, if there is a suspicion that infringement is made. This is a costly process. The European system with "looser pays", does not share the same problem as the courts evaluate the penalty based on value[29]. If the value is low, then the penalty is low, and also the probability to win a court case – which is not guaranteed – has to be taken into account by the litigant. This rule appears to put some checks and balances regarding enforcement based on value. The rent seeking firms may also come back with a second law suit shortly after the first, as information of ownership can more or less be legally hidden (shell-companies) and no updated registry exists. This is a clear system failure, where the incentives are not to enforce the economic value of a patented technology, but use court costs as means of some "extortion".

The response to this systemic abuse is to not license under threat of court costs but to go to court and pursue annulment of patents, showing the low value, thus somehow impose a more symmetric cost on the litigant, making the business model less profitable (or unprofitable, running these firms out of business). Such actions discipline the systemic abusers and teach them that if they want a license they should come with valuable technology and also full disclosure of other patents owned (information issue). Also in this case, we see that self-restraint when it comes to patent quality and value is a key in sustaining exchange and this strategy.

In addition firms increasingly go to lawmakers and try to amend the court proceedings; lobbying legislators is something done to "correct" this systemic error. This topic is a complex issue and solutions proposed appear favor the hierarchical business model, which was used more 100 years ago than today, and less cooperation through markets. Such attempts thus appear to have the aim to create incentive compatible rules for the *firms'* strategies to operate and create trust. However, from an *economic* point, the incentives aught to be compatible with social gains, which is a much more challenging task. Strategies 2, 3 appear much more compatible than 4 in this respect.

Trust in each others actions is thus created by going head to head with the systemic abusers and basically try to make their business model unprofitable unless valuable technology is presented, either through repeated court battles or lobbying for better laws. In such a case the inventor's rights are honored.

The *messages* sent are thus following through with court proceedings, annulment procedures with the patent office and willingness to pay for valuable technology. This systemic abuse is not easy to counter as a small firm and appears need a change of

[29] Currently there is a discussion on the US to look into this problem of enforcing low value patents, hoping to halt such systemic abused, deemed inefficient to innovation.

incentives. The property rights on these *messages* aught to be changed to change the incentives to favor high value patents.

In all these cases the common *theme* appeared to be that self-restraint regarding litigation (enforcement), opportunistic behavior (hold-up) and time value of returns in the interest of the client (licensee), was informally or formally contracted. As noted, this was achieved through different mechanisms, used in the different strategies by the firms operating diverse business models. Messages, communicated using the mechanisms, were used to arrive at the outcome of a sustained state of trust in each others actions, together forming a language of trust. These messages can be seen as part of a process to achieve the intended outcome of trust in each others actions, a process that was different in each strategy. The property rights on communication of these messages are therefore important in an economic system based on inventions of new technology. If the contracted trust could *not* be sustained, a change of strategy towards less cooperation (hierarch) was made. Each strategy thus resulted in that trust was achieved in each others actions not to infringe or sue for business essential, extant or future patents, reducing the uncertainty in the value of the future cooperation to a level where *rational* investment decisions could be made in innovations to achieve realizable and sustainable gains from exchange in patented technology.

Of particular interest appears the contract with capture period option that was used to move closer to an asset market in ideas. The contractual arrangements (formal and informal) follow a pattern of initial steps in institutional arrangements towards more impersonal exchange in patented technology. The behavior, based on the messages, appear to cover assertion of residual ownership.

A second, economic, dimension was observed, search costs, and is developed further in the next section. These economic and sociological observations also appear to lend themselves to generalizations beyond patents such as international cooperation. Such possible generalizations are elaborated on in the last section.

Table III summarizes the strategies and messages used to create trust in each others actions motivated by subsequent gains from such exchange.

Table III: Messages (language) used to create trust in each others actions by means of mutual (multilateral) self-restraint, as firms exchange patented technology under uncertainty.

Strategy	Policy	#	Message	Self-restraint mechanism
Stay clear	Mutually Assured Destruction	**1**	Build up massive patent portfolios in order to increase uncertainty in possible litigation situations, deterring others from suing and infringing as there is certain overlap on both sides.	Cost of litigation mutually prohibitive, enforcing property rights.
		2	If informal contract is breached then suing each other in court, which will deter further action.	
Strategic alignment	Honoring the inventor	**3**	Contract with capture period option, offering mutual access to any future technology during contract, and not beeing sued	Completely open sharing of everything (cannot hold-up or negotiate on each patents), enforcing contracts (and property rights)
		4	If formal contract is breached (in fields of use or after term expired) then suing each other in court, which will deter further action.	
		5	If infringements made then no extention of contract possible, i.e. "stay clear" strategy is option	
Marginal transactions	Honoring the inventor	**6**	Contract not to sue, on specific patents and fields of use	Court litigation based on penalty proportional to value of patented technology in product/service markets
		7	If formal contract is breached (in fields of use or after term expired) then suing each other in court, which will deter further action.	
		8	If infringements made then no extention of contract possible, i.e. "stay clear" strategy is option	
Systemic abuse	Litigate to enforce, based on "cheap" low value patents	**9**	Threaten to litigate in order to agree on license under threat of high court costs	Massive court litigations by defendants to anull ligitants patents, imposing cost on litigant to make business model unprofitable
		10	If litigant comes back too often or only with low value patents, then defendant tries to anull patents through court proceedings, to run litigant out of business or change behavior	

When portfolios with thousands of patents are to be evaluated, in practice, only a few are valued making agreements often net-agreements. The big portfolios are reduced to a few discussion patents where value is clear. In courts also only a few patents (or claims) are dealt with, not whole portfolios. This makes it complicated to defend property rights with courts alone, resorting to additional mechanisms. Contracts of self-restraint are needed to honor the inventor, not to sue, to have a functioning trade in ideas. Trust in each others actions must complement trust in courts proceedings.

We can see these strategies as four steps in a progression from personal to impersonal trust through formal and informal contracts. The economic consequences of these contracts appear to be that the agents do not trade on the margin, but on some other longer-term value or capabilities. This is a testable hypothesis in an experimental environment, and a controlled laboratory experiment has been designed to investigate this. The mechanisms clearly point towards strategies moving away from separation and litigation to cooperation.

4.3 Comments on some observed economic system dynamics

4.3.1 Market access: Implications of patent portfolio size

From an institutional economic policy perspective the size of the portfolios needed to sustain the diverse strategies is interesting as this indicates the research and capital needed, i.e. the size and balance sheet of firms, to sustain trust in each others actions. Observations on portfolio size indicate that very different sizes are needed to reduce uncertainty in the strategies. Such a policy is thus an extension to the institutional constraints to reduce risk in transactions and exchange (the fundamental rational for institutions). Here an incentive for productive cooperation in the creative process is at heart, requiring reduction in uncertainty. In the case studied here, strategies requiring smaller patent portfolios would be necessary for broader inclusion of human ideas. Figure 2 shows the approximate relationship between patent portfolios sizes needed to adopt a certain strategy.

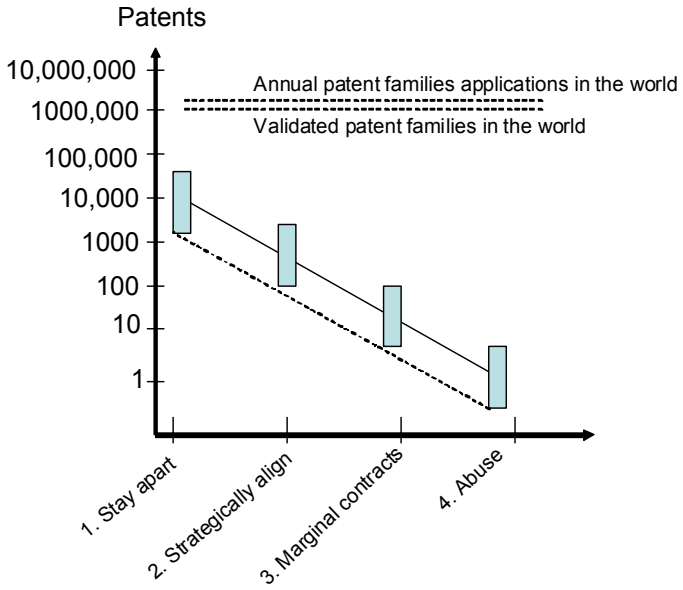

Figure 2. Size of patent holdings to sustain strategy of trust.

In this study, contractual agreements and search costs have been seen as decisive. It appears that institutional and tax policies that give incentives to move from strategy 1 and 4 to 2 or 3 are compatible with social goals of growth in productivity enhancing patented technology, making the selection process more demand driven, more internationally inclusive and more competitive.

4.3.2 An economy of scale of 1

This shows the challenge of socio-economic policy: To reach the individual inventor level. A key policy question then becomes whether individual inventors (or small teams of inventors) aught to be a topic of economic policy. That would definitely challenge 70 years or more of reliance on economies of scale economic policy, promoted by the industrial approach of mass production (and seen by politicians as the source of job creation). Perhaps thinking of economics in terms of the "second economic revolution" is

more fruitful? That approach allows for a discussion on economic structure, not pre-determined by an "industrial" approach as the economic engine[30]. The proposition here is that integration of technology and science aught to be structured in a more productivity enhancing way through a selection process in a market (not an invention-innovation hierarchy) which started by the creation of the patent system in 1474 offering *tradable* patent rights (initially *importing* technology). The incentives aught therefore, it seems, be more compatible with producing protected productivity enhancing technology than "more of the same" products and services at "lower cost". A rebalancing of incentives towards inventive activity is needed, creating a more dynamic economic system. Higher cost may thus be better than lower cost (within some limits), as the creative process gets funding, increasing productivity through new technology, not only scale. A producer market in ideas appears to solve this problem, by separating inventions (technology selection process) and innovations (products, service selection process where EOS matters).

This change towards one (1) can be seen in 3D printing, flexible manufacturing, innovation parks, past century's tech clubs, incubator and, maybe, also science parks (which can be seen as a first recognition of the need for more dynamism in the economic system).

4.3.3 Concentration of inventive resources

Such economic structure of inventor and innovator coordinating in a market would be the anti-thesis of Robinson (1977). A producer market thus creates competition between inventions that can be used in new innovations, and more-of-the-same-innovation, opening investment opportunities for the rational investor. Clearly the trust problem between inventors, traders and innovators is a key ingredient in such an economic system.

The economic structure (EOS) may have concentrated the inventive resources to very large firms, without strategies for exchange with moderate patent active firms. These smaller firms are typically startups, introducing new ideas. This means that barriers of entry of inventions may have been increasing, reducing the dynamics. Economic use of technology in a broader way, with specialized firms pursuing different applications of the same technology adding to the dynamics, of the economic system seems to distribute new technical ideas further than a structure of hierarchical inventor-innovator firms who largely focus on one application of the patented technology. Robinson (1977) lamented the crisis in the 1970s of the development of new products and services as large firms "monopolized" new technology. However without apparent discussion of economic structure, rather effects of concentration of capital in the hands of the few. More *internationally* tradable right – at the scale of 1 – may therefore be a fruitful source of further economic policy investigation.

4.3.4 Mutually Assured Self-restraint

The conclusion of the study points at that all strategies appear to have at its core a formal or informal contractual agreement to "honor the inventor" on the one hand and refraining

[30] One reason of challenging this approach is that today the economic system in the developed economies are about 60-80% services, and even in developing countries services dominate.

from opportunism on the other by mutual (or multilaterally: inventor, intermediary trader, innovator) self-restraint. One could say that the strategy space of mutually assured *self-restraint* (MAS) is broader than mutually assured *destruction* (MAD) and includes at least four strategies to achieve trust in each others actions. Implications of MAS appear to be that policy aught to facilitate enforcement of both tradable patent rights and contracts based on potential economic value. The enforcement of both ownership and transactions allows for uncertainty to be reduced so rational investment decisions (choices) can be made.

If self-restraint is not upheld, there are costly mechanisms to correct that. If institutional policy would be implemented in this area, a key focus would be for less costly mechanisms to be implemented (administrative patent procedures, patent quality, court cost). It is thus not only a "better" patent system (in terms of for example quality) that is needed, but a better contract law and court proceedings that give useful property rights on *communication* (what messages can be sent and received) starting at the individual inventor level. The discussed messages represent elements of such an institutional development.

4.4 Search costs

4.4.1 Search costs and impact on strategy choice

In addition to the sociological concept of self-restraint, an economic concept, *search costs*, was observed as being critical to the choice of strategies to create trust. This concept interacts with the ability to create trust in each others actions. The costs reported here expressed by basically all firms refer to:

A. Patent system:
1. finding prior art (a classification problem),
2. a digital divide issue (access to databases, internet, etc),
3. identifying legal validity, geographic validation and
4. ownership of patents (currently not updated)

B. Corporate law
5. indirect ownership (shell companies)
6. licenses of patents (private information)
7. discovery procedure costs (US)

C. International law
8. injunction procedures
9. international prior art searches

These and many other costs are key for the firm respecting others patents to simply *stay clear* of others patented technology. Today these costs are prohibitive for most companies if not even not all. It is thus virtually impossible to completely stay clear and not infringe. Such uncertainty works three ways: (i) the inventor may not be able to license technology (ii) the traders cannot trade as it is illegal to license invalid patents, and (iii) for innovators who cannot be certain of the value of the technology and its

exclusive use or ownership, to mention some cases. These search costs creates a situation where infringements are inevitable and, together with expensive court procedures, limits the strategy space for cooperation though patents as described in the strategies.

In the study the conclusions appears to be that if search costs are high then strategies 2 and 3 are less likely. Thus high search costs favor strategy 1, "staying clear", limiting gains from exchange in technology and strategy 4, "systemic abuse", which use uncertainty of ownership, hiding information, etc to extort possible infringers.
High search cost, an information, risk and cost problem, thus interacts with the strategies to create trust to reduce uncertainty. Search costs are therefore a key parameter in connecting the economic dimension of the problem to the sociological problem of trust. Table IV shows the relationships discussed by the interviewed firms.

Table IV: Search costs and strategy to create trust in each others actions.

	Strategy			
Search costs	1. Staying clear	2. Strategic alignment	3. Marginal transactions	4. Systemic abuse
Low	(x)	x	x	(x)
High	x	(x)	(x)	x

x indicates strong correlation and (x) weak correlation based on interviews.

This division of the economic and the sociological problem is the basis of the *experimental investigation*, representing treatment variables of search cost and contract. High search costs facilitate the creation of a rent seeking business model, that of infringing and suing, which may result in that the value from the invention is reduced (by theft) from the inventor, resulting in less cooperative strategies from the inventor as the only possible response (choosing the hierarchy strategy). This reduces the potential growth of technology through exchange and, in addition, loss of signal for the direction of science, to support further inventions. The rational law breaker (thief) always chooses dominant strategies (Smith, 2004, p. 69), which may be created through high search costs, in turn a possible policy issue. The loss of cooperation in the use of patented technology thus has impact on both the direction of patented technology and for the direction of science.

4.4.2 Discussion of search costs in relation to policy

One particular feature in the US patent system making search costs high was the possibility to *hide* ownership of patents through shell companies (ownership only has to be reported if above a certain threshold of ownership), and possibly other mechanisms. This was used systemically in the abuse strategy, to be able to keep private information on ownership, thus be able to sell a portfolio on slices and many times. This attempt to "bundle" patents does not allow the buyer to bid for "bundle" that he is interested in as a whole, and being unaware of whether technically related patents will end up with competitors, or more often, the abusing firm could come back and sell another set of patents right after. See under abuse strategy for resolution mechanism. Other mentioned costs are due to lack of registry for updated patent ownership registry (who owns what),

patent license registry[31] (who has access to what, which is a strictly private business today)

Patent classifications is another area, which allows for systematic "hiding" of inventions by splitting up an invention in many patents under different classes (a common strategy of patent applicants), creates such search costs. The international patent classification system, base largely on the European patent classification system appears more helpful, as it has a clearer technology focus than the US patent classification, which does not have the same structure. A classification that better captures technology areas, and is followed by the patent offices, would help in making the patent claims more clearly connected to an inventive technology.

Patent quality was a recurring theme among the most active patenting firms as mentioned. One dimension of this it that too many patents without real technological merit are granted (this is a contentious issue). A rule of thumb among patent professionals[32] used to be to have a grant rate or 50%. This rate varies a lot and was in the US above 90% a decade ago. That resembles more a registration system than examination system. Many other countries have similar procedures (and some, at least in the past only had registration and validation took place through courts). There has however been a pushback in the USA[33] and the grant rates are now lower. The problem from a search cost perspective is that a lot of patents that should never have been granted is out there, and to stay clear from them, creates an "impossible" situation for companies using patents productively. These patents of low quality are also "feed" for systemic abuse firms to threaten to sue for possible infringement.

There are also other search costs involved such as access to patent information (databases), data collection and analysis of their use in products, validity data (which patents are upheld, where), company data, and internet, i.e. the digital economy's toolbox.

5. Economic theory consequences of contracts and search costs

The main purpose of this study has been to investigate the strategies firms use to create trust in each others actions, in an economic-sociological environment of genuine uncertainty. The hope was to give input to economic theory regarding how to better handle uncertainty and risk, by first solving the sociological problem of uncertainty and then the problem of risk. Some possible consequences are here outlined.

The solution to the problem of uncertainty that is used appears to be in contracts of multilateral self-restraints. This implies that, since the marginal value of future inventions cannot possibly be known, and that opportunistic behavior such as hold-up cannot be

[31] It is unclear whether a compulsory patent license registry would be in the interest of economic development. Incentives for voluntary publication of these licenses may be better. Forcing publication of licensing may result in less licensing, as they reveal strategic intents, like patent applications do. However, this topic is an issue of study and

[32] Ref. to personal communication with the head of international relations at the Swedish patent office, a senior patent professional with 30 years in the patenting world.

[33] Why reference to the US? Many countries look at the US for guidance on patent office policy so what the US does matters internationally.

excluded, contracting the exclusion of and enforcing such behavior, informal (personal) and formal (impersonal) contracts on patented technology, the contracted price cannot possibly be on the (genuinely uncertain) marginal value of the next invention. It has to be on some other value, in order for agents to make rational decisions (choices) regarding investments in further products and service innovations using the patented technology. Solving the sociological problem of trust implies that some patented technology would be overpriced and other underpriced ex ante, if evaluated in ex post situation.

This puts focus on three areas: residual ownership on technical ideas, contracts and market prices. The quality of patents, their disclosure, claims, and classification (i.e., their specification), is often viewed as necessary condition for ownership and the creation of an asset market in the first place. This means that specifications of the property rights (like their quality) need to be part of any contract. The contracts, which include implicit or explicit self-restraint giving their enforcement, would be priced, possibly, according to some long-term average value[34], or, the risk appetite of buyers "betting" on that the sellers will invent more profitable technology in the future higher than that average. This creative process requires further investigation. Price discussions would thus include the (economic) effectiveness of the management of the uncertainty through self-restraining contracts and the search costs related to quality of assets in terms of ownership.

This suggests that economic structure depends on assets and self-restraining contracts in determining the value and thus market price. We posit that firms are thus organized along the lines of ability to solve this sociological problem of trust in each others actions, not simply residual ownership and transaction costs. Including these dimensions characterizing what firms do to manage genuine uncertainty, into a formal theory would be a next step.

In all these cases the discussion on market efficiency under risk (Arrow, 1962) needs to be ameliorated for uncertainty.

If the findings in this study can be verified, such a discussion could be made along the lines of the four strategies:

1. Staying clear strategy – uncertainty in opportunistic and rent seeking behavior.
2. Capture period contract –uncertainty to be managed through contracts. This is not a marginal value.
3. Marginal contract – well-seasoned technology with proven value can be traded at "value" or portfolio value.
4. Abuse – systemic failure (not market failure) give incentives to hide information.

In such a discussion attention may include the *direction* the patented technology created and exchanged is taking in terms of its benefit for economic development. The derivate effect would be the *direction* science takes in terms of its benefit for technology for which there is an expressed (signaled) demand.

[34] The best forecasting estimator is the relatively simple: forecasted value = long term trend(1-a) + last value*a. The long-term trend could be the average. Ref. to personal communication with Prof. Spyros Makridakis, INSEAD.

Proposition: The economic consequences of these formal and informal contracts appear to be that the agents do not trade on the margin. That could possibly be average value or "betting" on a value higher than average given that incentives are in place to invent towards an expressed demand. This is a testable hypothesis in an experimental environment, and a controlled laboratory experiment has been designed to investigate this.

6. Implications for other fields

The strategies appear to have some generality for other areas outside creating trust in exchange of patented technology. Several examples have been found of which a few are mentioned here: US-Russia relations, the first patent law and limiting state monopolies, and international institutional development.

6.1 The limits of partnership

In "The limits of partnership" (Stent, 2014) explores the relationship between the US and Russia the last 20 years. The partnership is partly about innovation between US-Russia, thus a partnership that strikes at the heart of economic cooperation and development.

Trust in each others actions has gone through "four resets" since that Christmas day in 1991 when the Soviet Union disappeared (George H. W. Bush, Clinton, George W. Bush and Obama). The Russian explanation is that although "every Russian President has begun his term with high expectations for the relationship and every term ends in disappointment because the United States has disregarded Russia's interests." (Stent, 2014, p. x).

If the findings reported here has bearing outside cooperation under uncertainty in exchange in patented technology, self-restraining contracts are needed and possibly an international commercial court. This may not be sufficient though but move in the direction of strengthened international institutional development may be needed as well, in today's multilateral world, where the two former super-powers now have to relate to a world of multiple "super-powers". See (Kissinger, 1994) for a foresighted discussion of challenges for the USA in finding a future role of USA in world diplomacy.

Stent comments that the central objective of Russia since 1992 ha been to "regain it status as a great power and be treated as an equal by the United States." (Stent, 2014, p xi) This is firmly how the firms operate in the "stay apart" strategy, as they try to find means of cooperation, through mutual self-restraint. The fallback strategy has to guarantee the continued prospering of the own hierarchy, and that can only be assured by mutually assured destruction to create trust in each others actions, not to "invade" or compete in each others markets and stop competition on technology in those divided markets. A sustained, but economically less efficient non-cooperative strategy than strategic alliance, or marginal cooperation is achieved. "The US interest has been to prevent Russia from acting as a spoiler in areas where the US has vital interests" (Stent, 2014, p. xi). Mutual self-restraint is a necessary step towards increased cooperation.

According to Stent, an American perception that a weak Russia I amenable to acquiescing to a U.S. agenda has created a visceral Russian determination not to be

treated as the US's junior partner. This, again, is what is observed by partners in a stay-apart strategy, where weak or no contracts and institutions exist to enforce individual, weaker, firm's rights. The alternative to such a strategy would be a shift towards an international contractual and institutional development process, where each party competes on specialties in a multi-polar world, not on a mutually assured destruction. The strategies found here may therefore be helpful to explain the rationale of increased formalization of international collaboration.

6.2 First patent law

The first patent law: 1474, 19 March, is an example in it self of contracted self-restraint:

> "There are men in this city, and also there come other persons every day from different places by reason of its greatness and goodness, who have most clever minds, capable of devising and inventing all kinds of ingenious contrivances. And should it be legislated that the works and contrivances invented by them could not be copied and made by others so that they are deprived of their honour, men of such kind would exert their minds, invent and make things that would be of no small utility and benefit to our State. Therefore, the decision has been made that, by authority of this Council, any person in this city who makes any new and ingenious contrivances not made heretofore in our Dominion, shall, as soon as it is perfected so that it can be used and exercised, give notice of the same to the office of our Provveditori di Comun, having been forbidden up to ten years to any other person in any territory and place of ours to make a contrivance in the form and resemblance of that one without the consent and license of the author. And if nevertheless someone should make it, the aforesaid author and inventor will have the liberty to cite him before any office of this city, which office will force the aforesaid infringer to pay him the sum of one hundred ducats and immediately destroy the contrivance. But our Government will be free, at its complete discretion, to take and use for its needs any of the said contrivances and instruments, with this condition, however, that no one other than the authors shall operate them."

The last sentence contacts self-restraint between the governments, thus limiting the previous royal monopolies granted to the friends of the king, creating some trust in the actions of the government, provided the courts would honor the law. The transition from personal to impersonal exchange thus goes through steps of contract and institutions to enforce contracts. Some research portray that "constitutionalizing patents" was a way limit monopoly rights handed out by kings, provide a way to impose self-restraint by governments (Nard and Morriss, 2004). Royal privileged (political processes) are thus turned into administrative processes.

6.3 International institutional development

Base on the proposition of self-restraint, an increase international cooperation would benefit, in terms of institutional learning, by an external input to the nation states.
The question maybe more how to get there, i.e. institutional learning, than the need for enforcement of mutually self-restraining contracts. Experimenting is a key here, thus, regional and limited multi-party agreements could result in this learning. One could see the G7, G8, G77, etc as such attempts to bridge the bilateral agreements with international, multilateral, agreements such as UN, WTO, etc.

In this spirit, a more temporal contract could be introduced, allowing for strategic alignment between states for a time. That may advance the institutional learning faster than long-term commitments where rules may be difficult to change. You don't want to change the rules too easily either, as it is trust that is desired. A length could be perhaps 15 years or 50 years or so (a rather long-term investment horizon for most firms). Hong-Kong with 99 years could be seen as such an example in international trade. This temporary institutional learning, would then lead to perpetual rules of markets.

Compare North on limited versus open access order (North, 1990), where he argues for rule of law for the elite. Here we may see a similar process among nations, coordinated through international rules and laws. However, the process by which this institutional learning could take place, based on the finding here, may suggest that temporal international contracts and agreements, allowing strategic alignment to take place – and be tested – may be a way to develop this international cooperation, rather than the difficult process of multilateral negotiations, often with political concerns dominating other concerns in society.

A more experimental approach may be able to include business, civil society and governments (as a rule maker and enforcer), creating a separation and coordination between diverse interests to better represent the whole society (not only economic interest, or political ambitions, or religious concerns or other special interest groups). Such as system would lead to more competition, thus, incentives to learn.

7. Conclusions and policy implications

We have discussed key aspects of what firms do to create trust in each others actions when exchanging uncertain current and future technology in patent markets (technically based on the patent systems). To resolve *risk,* information (an economic problem) is required to create a probability distribution of future events, but to resolve *uncertainty,* where information is not available, trust in each others actions is needed (a sociological problem). The economic treatment of risk in the literature is based much on the Arrow-Debreu security with markets on state of *nature* (in a broad sense). In markets in patents, state of *the art,* is traded which is far more uncertain than state of nature (which can be investigated by studying nature) as these are new, untested (mostly) technical solutions created by people (which involves uncertain human behavior and ideas). Different cooperative strategies were identified to resolve this uncertainty by the firms, depending on the business model, patent system strength and search costs (to stay clear of patent claims).

The attempt has been to separate the sociological problem from the economic problem to better understand the *process* by which uncertainty is managed (reduced) and governed in these cooperative environments. The cooperative strategies, four in total, all appear to be built on *informally and formally contracted mutual and multi-lateral self-restraint* among the trading partners (inventor, intermediary traders, innovators, financers[35]). The strategies identified are 1: "staying clear" of each others technology areas "clearing" technology indirectly in the product/service markets, 2: "strategic

[35] Financiers were not part of the interviewed firms but mentioned in the discussions as "trading partner".

alignment" with capture period contracts including future patented technology for a period, 3: "marginal transactions" of patents in use, thus market values are "known", and 4: "systemic abuse" where uncertainty of ownership of (mostly) low value patents is used to extort, backed by prohibitive cost of enforcement, avoiding a negotiation on (the low) value.

That contracted self-restraint creates trust in each others *actions* not to sue, hold-up or behave opportunistically, reducing uncertainty in the informal or formal relations making rational decisions for investments possible (where the strategies to create trust can be sustained). They create an economic system where sustained exchange can take place. The process of creating trust and *reducing* uncertainty in an economic system can thus be described by a selection of strategies moving from strategy 1 and 4 to strategy 2 and 3, where direct negotiation on the value of patented technology is possible (in 1 it is only indirect and in 4 it is the "cheaper" alternative to court costs). This selection is in turn dependant on the incentives to trade technology, i.e. realized gains from trade given that trust can be maintained to reduce uncertainty.

A series of *messages* were used by firms to create trust in each others actions, different for each strategy. These messages then form the *language of trust*. The messages appear to assure "freedom to act" in the innovation market by clearing the patented technology rights through different *mechanisms*: for strategy 1: mutually assured destruction (MAD), 2: mutually assured self-restraint (MAS) in various licensing agreements, 3: limit field of use (FOU), geographic markets (potentially in connection with standards) and 4: running systemic abuse firms out of business (SAB) by annulling low value patents (with patent offices) to dissuade litigation based on prohibitive court costs.

A possible next step would be to *develop* these mechanisms further to tie them closer to the strategies and messages. Such a study may help in enabling a more incentive compatible policy to move from strategies 1, 4 to 2, 3.

Strategy → Messages → Mechanisms → Policy

The choices of strategy appeared also to be directly impacted by "search costs" to clear any patent infringement. These cost include finding the rightful *owner* of a patent (currently no updated registry exists, shell-companies are used to intentionally hide ownership), finding patents that may *infringe* new inventions (classification issues, unclear disclosure and claims) and finding *overlaps* between portfolios, to give some examples. In essence this is an asymmetric information problem (an economic problem) that appeared to interact directly with the choice of strategy to create trust. These search cost require a systemic approach to the patent system, so that economic value will be the basis of negotiation, not overshadowed by diverse search costs. *Quality* of patents and public information on legal *ownership* are therefore key issues.

All strategies are thus not available to all firms, which cannot be efficient, as incentives to invest in new inventions are then reduced (at the discretion of some firms). Only the largest firms can get the access they want, and even they have issues with systemic abuse. To send a MAD message one needs to invest in a very large portfolio (thousands or tens of thousands of patents). Only then can the uncertainty in claims be *high* enough that MAD is assured if core technology is infringed. To send a MAS

message huge research portfolios are needed to leverage research capabilities as net-licensing fees may be too expensive. A FOU message, a contract and price negotiation is considerably less expensive, but these represent often technology in use not new technology, which drives future investments. To send a SAB message is relatively inexpensive but to *respond* to a SAB message is expensive and these firms often settle out of court.

The messages thus appears to first assure *ownership* of technology invested in to exclude (use them in own innovations) or trade, and then assure *terms of trade* (contracting a diverse range of licenses, cross-licenses of portfolios, parts of portfolios or individual patents). In the end the messages serve to assure self-restraint that the parties will not sue, nor hold-up or behave in an opportunistic way in pricing new technology. Those costs clearly depend on a culture of "honoring the inventor". Incentive compatible decisions in patent markets are thus not on the margin, but on a more long-term relation of trust in each others actions. The hope is, as a next step, to integrate trust in economic theory, based on the sociological process to manage uncertainty through informal and formal contracts.

Enabling increased selection of strategy 2 and 3 will likely create a more dynamic economic system with less (concentration of) ownership of technology in hierarchies, as incentives to invest in new technology and trade it are likely higher. A more competitive technology producer market likely leads to a higher growth rate in economically useful technology (i.e., increased productivity) due to increased demand side knowledge revealed in the bidding process of prices, thus potentially higher growth in the economic system.

It also appears that these four strategies also may have merit in more general applications such as international relations and international institutional development where attempts are made to forge a more cooperative world between nation states, as well as in sports, family, and other sociological problems where trust in each others actions is a key element.

In summary institutional and taxation policy, as well as further economic theory development, aught to be informed of these strategies and messages to solve the sociological problem of trust in a way that gives (i) incentives to move from strategy 1 and 4 towards 2 and 3, where exchange between firms takes place, and thus increased specialization and learning, (ii) accessibility to these strategies (including their cost) giving property rights of communication in the language of trust down to the *individual* inventor, changing the incentives to a much more global, and sustainable, inclusion of exchange in patented technology. A policy initiative also aught to lower search costs further enabling choices of more cooperative strategies.

Such trusted cooperation would thus give incentives for a *direction* of development of new patented technology towards more economically useful technology, and by its derivate, the direction of science, to support further creativity and exchange of human ideas in a trusted socio-economic system.

Finally, such strategies can enable exchange in technology North-South, integrating future technology developed elsewhere in a single, integrated, market in ideas, possibly advancing technology towards higher (sustained) growth, enabled by a common language of trust.

References

Arrow, J.K., 1962. Economic Welfare and the Allocation of Resources for Invention. Rand Corp.
Arrow, J.K., 1952. Le Rôle Des Valeurs boursières pour la répartition la meilleure des risques.
Aumann, 2004. Assessing Strategic Risk. Work. Pap.
Bernoulli, D., 1738. Exposition of a New Theory on the Measurement of Risk. Econometrica 22, 23–36.
Coase, R.H., 2009. Markets, Firms and Property Rights. Inf. Econ. Proj. Lect. VIDEO.
Coase, R.H., 1990. The Firm The Market and the Law. Chic. Univ. Chic. Press 1990.
Coase, R.H., 1960. The Problem of Social Cost. J. Law Econ. 3, 1–44.
Coase, R.H., 1937. The Nature of the Firm. Economica 4, 386–405.
Commons, J.R., 1932. Problem of Correlating Law Economics and Ethics, The. Wis. Law Rev. 8, 3.
England, 1623. English Statute of Monopolies of 1623, 21 Jac. 1, c. 3, The Original Source of the Anglo-American Patent Law.
Geneva, 1994. WTO/TRIPS Agreement.
Grossman, S.J., Hart, O.D., 1986. The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration. J. Polit. Econ. 94, 691–719.
Hart, O.D., 1988. Incomplete Contracts and the Theory of the Firm. J. Law Econ. Organ. 4, 119–139.
Hart, O., Moore, J., 1988. Incomplete Contracts and Renegotiation. Econometrica 56, 755–785.
Kaufer, E., 1989. The economics of the patent system. Harwood Academic Pub.
Kissinger, H., 1994. Diplomacy. Simon and Schuster.
Nard, C.A., Morriss, A.P., 2004. Constitutionalizing Patents: From Venice to Philadelphia.
Nash, J., 1951. Non-cooperative games. Annals of Mathematics, pp. 286–295.
North, D.C., 1990. Institutions, institutional change, and economic performance. Cambridge Univ Pr.
North, D.C., 1981. Structure and change in economic history.
Ostrom, E., 2010. Beyond Markets and States: Polycentric Governance of Complex Economic Systems. Am. Econ. Rev.
Ostrom, E., 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press.
Paris, 1883. The Paris Convention for the protection of industrial property. Int. Treaty.
Plant, A., 1934. The Economic Theory Concerning Patents for Inventions. Economica 1, 30–51.
Robinson, J., 1977. What Are the Questions? J. Econ. Lit. 15, 1318–1339.
Schumpeter, J.A., 1942. Capitalism, Socialism and Democracy.
Schumpeter, J.A., 1934. The Fundamental Phenomenon of Economic Development. Schumpeter Theory Econ. Dev. 57–94.
Schweik, C.M., English, R.C., 2012. Internet Success: A Study of Open-source Software Commons. MIT Press.

Smith, V.L., 2004. Human nature: an economic perspective. Daedalus 133, 67–76. doi:doi:10.1162/0011526042365528

Stent, A., 2014. The Limits of Partnership: U.S.-Russian Relations in the Twenty-First Century. Princeton University Press.

Szenberg, M., Ramrattan, L., 2014. Eminent Economists II. Cambridge University Press.

Ullberg, E., 2012. Trade in ideas: Performance and Behavioral properties of markets in patents. Springer Inc., New York.

Ullberg, E., Rodriguez, E., Stormby, N., 2002. Risk Management - From portfolio strategy to value creating system strategy. Geneva Pap. Risk Insur. - Issues Pract. 27, 467–476. doi:doi:10.1111/1468-0440.00185

Venice, 1474. Venice Patent Law of 1474.

Vernon L. Smith, 1982. Microeconomic Systems as an Experimental Science. Am. Econ. Rev. 72, 923–955.

Williamson, O.E., 1993. Calculativeness, Trust, and Economic Organization. J. Law Econ. 36, 453–486.

Williamson, O.E., 1979. Transaction-cost economics: the governance of contractual relations. J. Law Econ. 233–261.