

The goal of this introduction will be to give the reader a general outlook of the economics of property rights with an emphasis on intellectual property. Most of the discussion is aimed at summarizing the literature but some commentary is original. Section 0.1 discusses the roots of the debate and the modern legal language way of discussing such rights. Section 0.2 aims to give some brief definitions of the kind of efficiencies economists concern themselves with and to discuss how these notions apply to the Coase theorem and property rights. Dynamic aspects of property rights and incomplete contracts are discussed in section 0.3. Finally some comments on economic arguments of intellectual property are reviewed in section 0.4.

## 0.1 The origins of the debate about private property

The roots of the debate about property rights originate in Ancient Greece by its two most famous philosophers, Plato and Aristotle. Plato's most famous work, the Republic, is a treatise on an idealized society, one that has managed to halt to a minimum its own deterioration from the perfect form. Plato's view of property rights is purely instrumental in that it is something that will help maintain the ideal society from deteriorating. Plato's conception of ownership is as an important source of corruption that creates clannish self-interest and considers the panacea of this influence to be the abolition of private property. Aristotle takes a stand against his former teacher in being one of the first defenders of private property. In "Politics" Aristotle reasons that without private property people would interfere in each other's affairs without being motivated by love. He viewed the act of waiving your rights to property against an individual as a way to be virtuous, and a limitation of this right would limit the ability to be virtuous. The debate between Aristotle and Plato has echoed for millennia, with various philosophers taking different sides on this debate. For instance Hegel defended property rights based on his theory of person-hood, stating that people are defined by their will and the only way to manifest their will is through physical objects. Philosophers even had views on intellectual property, Hume for instance claimed that property should be placed on only goods which are scarce<sup>1</sup>.

Perhaps the most influential modern non-economic normative view of property is John Locke's theory of 'homesteading'<sup>2</sup>. Locke's view of property rights is as a method of linking a person who is creating value to that value. This is done by mixing one's labor with the object or land which makes the physical object inseparable from its founder. The view is often rather vague as it does not distinguish between the different amounts of value added

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<sup>1</sup>see Plant (1934a) for views of various philosophers

<sup>2</sup>Locke (2014)

and the scope of the homesteading.

Economics has always focused not on the origins of property but on its effects. Using this lense, perhaps the most famous critic of the Lockean theory of property was Karl Marx who claimed the opposite, that private property is the means by which workers become alienated from their labor. The logic behind this is rather simple: if an employee adds a number of hours' worth of labor, he will necessarily be compensated less than that number of hours' worth by the property owner otherwise there would be no way of making profit, hence exploitation. This is one of the first views of property which focused on the dynamics of property, specifically here, the dynamics on wealth inequality. However these kinds of interpretations have been superseded as value has been associated not with inputs but by the tastes of agents and the relative scarcity of resources. Similarly profit could be entirely explained by other factors such as the relative advantage firms have in information, whether it be an edge in production, taste, impulses of consumers etc. This does not entail that property is disconnected from value, merely that value is not caused related to labor, though it is correlated.

Perhaps the first fully prescriptive system of property was articulated by Henry George <sup>3</sup>, which aims to reduce some of the dynamics described by Marx. Henry George devised a system where property is temporarily allocated to the highest bidder. What is ingenious about the modern version of the Georgist scheme is that it aims to eliminate land rents by making tenants bid for their own rents. This creates a system where people will only earn their labor rent and not the land rent of value. Perhaps the most known response to this is the view of Hayek <sup>4</sup>. In this view the function of property is not homogeneous across individuals and making ownership temporary is prescriptive in not only the system of property but also in what agents should pursue. For instance, if an agent uses land to pursues non-monetary goals, the tendency will be for that agent to be replaced by an agent who pursues monetary goals since those goals will be aligned much closer with the ability to bid. In other words the effect of the property system is not simply to allocate goods efficiently but to allow agents to discover their own goals.

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<sup>3</sup>George (1973)

<sup>4</sup>von Hayek (1991)

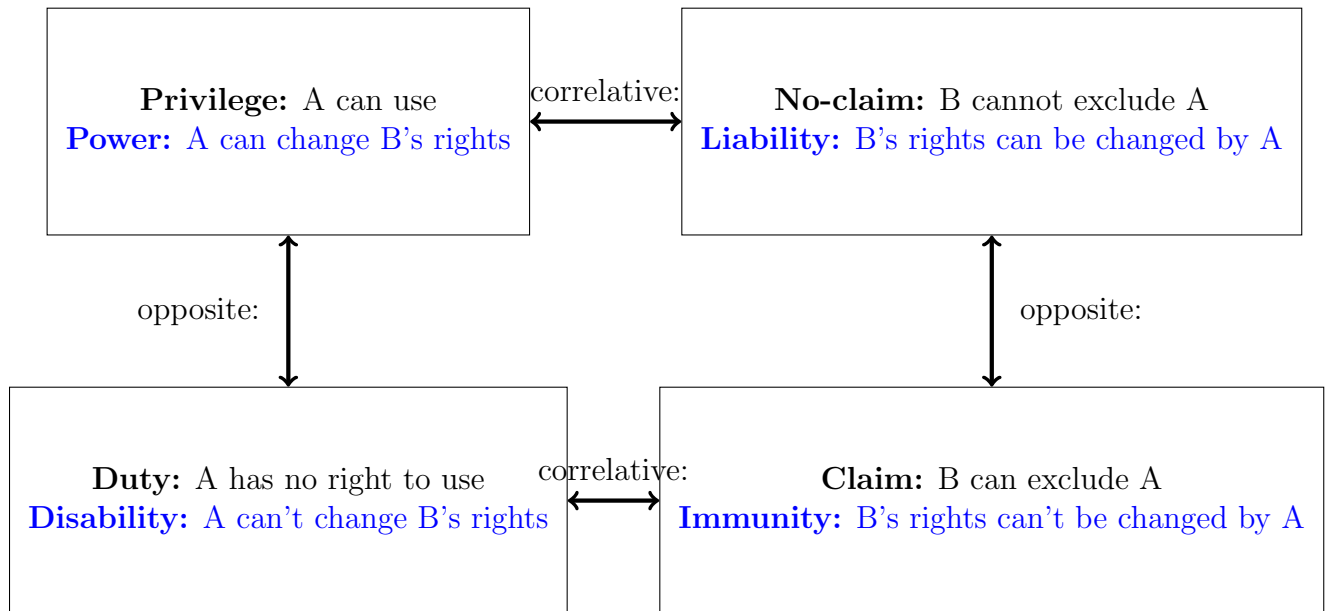


Figure 1: First order rights, Second order rights

### 0.1.1 What is a property right?

What is a property right<sup>5</sup>? A tentative answer to this question are: property is simply the default contract, that is, if people do not agree on a contract, property is what is taken as the baseline. 'Property as the default' view is simple enough: Person A can contract with person B that person B will not touch or use item z without A's permission. This in fact requires no property right at all. What does require a property right is that all other people will also not be able to do with z as they please. If agents could all simultaneously consent or if there were but two agents who could contract, there would be no need for property rights. Indeed property rights rely on the inability to contract or simply the costliness to contracting with all agents simultaneously. This basic reasoning is the motivation between incomplete contracting(which is discussed in section 0.3.1 )

### 0.1.2 The language of property rights

The most basic method of discussing property rights is using jurist legal language<sup>6</sup>. Discussion of rights is separated into different hierarchies but in most applications only two levels are needed. First order rights, which describe the direct rights an agent possesses, usually

<sup>5</sup>The presentation borrows from Munzer (1990)

<sup>6</sup>See Hohfeld (1917)

the positive rights to act on an asset or to exclude another agent. The right to use is called a "privilege" and the right to exclude is called a "claim". These rights are zero sum in the sense that if all agents have a "privilege" then no agent has a claim. On the other hand if at least one agent, agent B does not have a "privilege", then agent B has a "duty" and there is some set of agents, A who either individually or collectively(perhaps democratically) have a claim right against B.

Second order rights are rights about first order rights. For instance when one talks of "power" this is in reference to the right to transfer, waive or annul "claim" and "privilege" rights. For instance, the right to change who can use the property is a second order right. One can also speak of "immunity", which means that one has the right for his "claim" or "privilege" to not be affected by others. Second order rights are about how first order rights can be changed and the possibility space of first order rights is increasing in power and decreasing in immunity. Second order rights may also have the feature of circularity, Agent A can have power over B, B may have power over C and C may have power over A.

Notice that if an agent has power over an object, this entails the ability to have first order rights. Both first order and second order rights may be under negotiation in contracts, the arrangements that can legally emerge are much narrower without power. Having power over an asset entails the right to destroy and to abandon, if someone does not have second order rights this entails the agent has no right to destroy or abandon. <sup>7</sup>

When does someone have the right to abandon or to destroy?

The contractual possibility of first order rights depends on the distribution of claims or privileges. If all agents have privilege rights on an asset then this naturally entails that the only contracts agents can draw are either committing to using or not using the asset. If on the other hand an agent has claim rights on an asset then that agent can also contract the exclusion of other agents from using an asset. If cost is independent of the number of agents one is contracting with, then there is no advantage to uniting claim rights upon a single individual. However, if approaching each agent is costly then it may be advantageous to allocate claims to a single agent. So while the contractual possibility space is entirely available in all cases, the property right regime can achieve the same contractual space with fewer parties. Similarly, the types of arrangements possible (corporations, partnerships, non-profits, licenses, bailments, non-voting common stock, trusts, agencies, employee-employer relationships marriages etc) entirely depend on second order rights. With this in mind we clarify how some property right paradigms fit into this conceptual framework.

To clarify ideas it is useful to know how this taxonomy matches with traditional economic

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<sup>7</sup>For an interesting analysis of the right to destroy/abandon see, [Strahilevitz \(2005\)](#), [Strahilevitz \(2009\)](#)

ideas. For instance clearly if there is a law that requires property owner A to allow access to B, this implies that agent B has a privilege of use, and implies that A has a no-claim, similarly this implies that B has immunity and A has a disability. A price control is a limitation on what price one can sell their good for, as such it is a "power" limitation in the sense that without a price control A could transfer the asset on wider terms.

The above puts a heavy emphasis on 'use' and 'exclusion', however the notion of 'use' in the case of land is a broad term that encompasses numerous rights that are separable. The additional rights that can be constructed from 'use' are: Access, the right to freely move within that territory; management, the right to control the internal organization of the land; Withdrawal, the right to extract things from the land; Alienation, the right to sell or lease<sup>8</sup>. Land ownership specifically has been summarized by the simple hierarchical relationship corresponding to the five rights, authorized entrant  $\in$  authorized user  $\in$  claimant  $\in$  proprietor  $\in$  owner (each level of the hierarchy adds a right).<sup>9</sup>

The two natural limits to the jural taxonomy are when only the state has second order rights and sovereignty. One possibility for the absence of a second order right is that all agents have privileges, this is termed *Open access* (open sea and atmosphere or explicit prevention of exclusion zones). Alternatively, the absence of second order rights could be when the state allocates claim or privilege rights to a specific group. This could look like a king choosing vassals or democracy selecting managers. *Sovereignty* on the other hand implies that someone has infinite order rights, if someone has the capacity to make someone else an owner, this can only be represented by an infinite recursion, however the specific scope of ownership will depend on the regulations in place. The scope of ownership has often been articulated as "the right to do with your property as you wish as long as nobody else is harmed by it". However such definitions are problematic as the notion of harm is too loose. A simple solution to this looseness is to revise the definition to "the ability to use ones property in any way one wishes as long as the *physical* characteristics of others property is not affected"<sup>10</sup>. Notice that this definition is not free from interpretation because the notion of 'physical' is not clear (for example: a change in air quality), however once the notion is adopted it creates an objective measurable standard that is open to external verification. We define the word *intrusive* in this physical sense.

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<sup>8</sup>Ostrom and Hess (2010)

<sup>9</sup>See Schlager and Ostrom (1992)

<sup>10</sup>Alchian (1965)

*Private property* is often a term used to describe some kind of constrained sovereignty. While both sovereignty and private property imply infinite order rights on the set of rights granted, the set of rights granted by private property is smaller. Private property does not entail that the owner has higher order rights on all possible uses. If we imagine the three sets below, private property implies simply that  $B \cap C$ . Private property is Sovereignty in the special case where  $B \cap C = C$ . These relationships are summarized in figure 2.

$A := \{\text{Possible uses of an asset}\}$

$B := \{\text{Non-intrusive uses}\}$

$C := \{\text{Intrusive uses}\}$

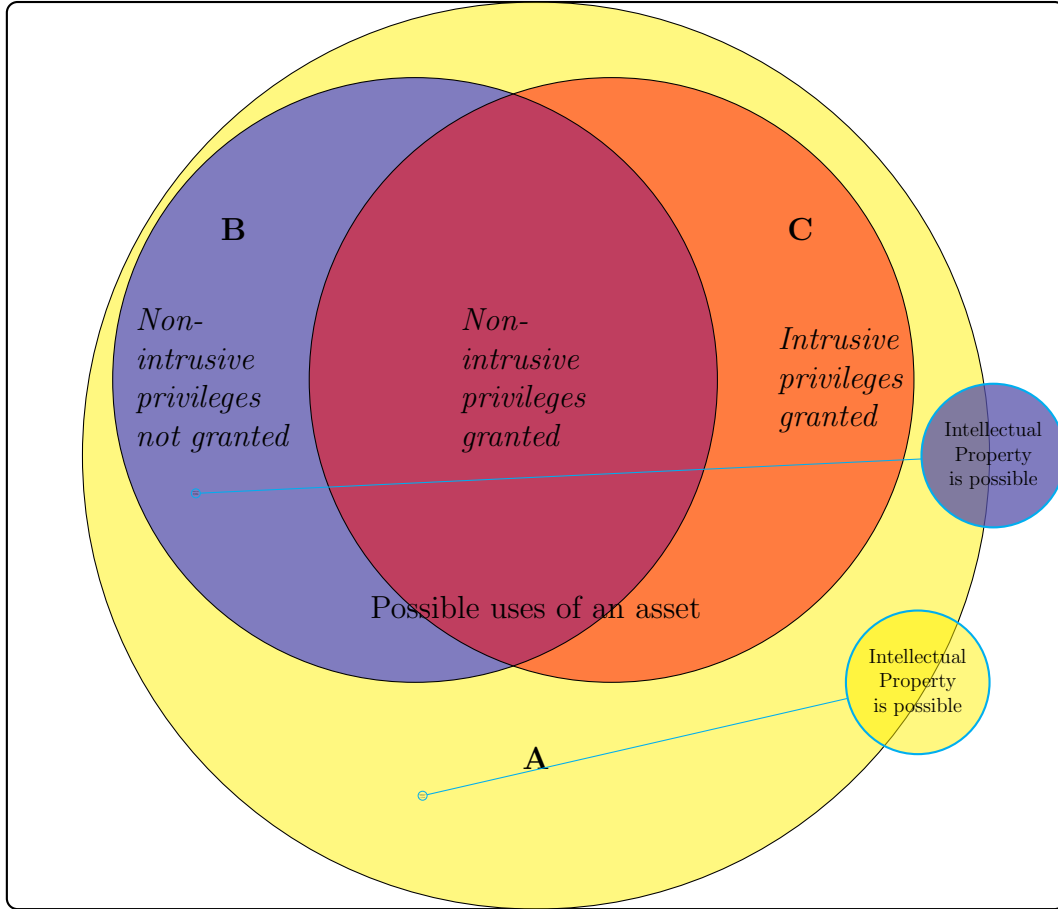


Figure 2: Intellectual property is only possible if a privilege is not granted

*Communal/Public property* on the other hand gives a subset of agents in society the right to use but not the right to exclude. Power is also given to a subset of agents, this may be

some community that aims to allocate fishing or hunting rights. However, since alienation or transfer is limited, this generally implies higher order rights are in the hands of the state. The distinction between communal and public ownership is how the government chooses to exercise its higher order rights. If they are exercised for the sake of public servants such as a military reservation, then it is called "public" and if not we call it "communal"<sup>11</sup>. The word 'communal' usually also implies that there is some kind of privilege that agents have over the land. In the limit, as the set of agents who can exclude is empty, communal property becomes *Open access property*. In general any regime with weak claim rights is a first come first serve type of property and agents operating in such a regime ignore the cost of use.<sup>12</sup>

There are other types of regimes which are less commonly discussed such as the *Georgian system of property*. The Georgian system of property is a system which temporarily grants first and second order rights to individuals for a given period of time conditional on the individuals having the highest bid. Since ownership is temporary, and no permanent right is possible, this implies no higher rights than third order rights. Additionally, agents no longer have the right to transfer ownership since the decision to keep ownership temporary and conditional on winning the auction is ultimately given to the state.

One way of presenting economics is as being the analysis of exchange, Adam Smith's two books are said to be about two notions of such an exchange, personal exchange and commercial exchange. These two notions correspond closely to the hierarchy of rights. To give a gift or to share something is within the sphere of personal exchange, as such agents need only have first order rights. Commercial exchange on the other hand is about impersonal exchange: such exchange is conditional and subsequently, depends on the ability to contract. The ability to contract on assets requires higher order rights; hence the degree to which a society can become a commercial society depends on how higher order rights are distributed.

The language presented is especially interesting for the analysis of intellectual property. Whilst each physical property can be seen as a list of rights and the matching of those rights to individuals or groups of individuals as described above, the concept of intellectual property is qualitatively different. The notion of intellectual property is a limitation of the first order rights of "privilege" on physical property. That is, if one has intellectual property on the concept of a wooden chair, this is in fact the limitation on the use rights of all owners of wood. Alternatively, there are instances where the law permits copying but not commercialization. In these instances the first order rights are not affected, but the second order rights of "power" are limited conditional on the use of the asset.

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<sup>11</sup>For a discussion of using common property as a policy tool see: [Ciriacy-Wantrup and Bishop \(1975\)](#)

<sup>12</sup>[Alchian \(1973\)](#) mentions how the Canadian government in 1970 set an upper limit to the number of seals to be clubbed which caused speed of hunting to be the competitive trait leading to over-hunting

## 0.2 The static economics of property rights

Is the change in allocation of rights substantive? In other words is this whole exercise just a redefinition but does not imply any changes in resulting actions? In theory, public and private property can both pursue the same kind of goals, such as profits and charity. In practice, once the incentives of the agents are taken into account, the theory of property rights becomes descriptive. A price control is an instance of a reduction of higher order rights, it is, in effect, a limitation on the conditions of transfer an owner make. A simple example of the effects of price control can be illustrated by an agent renting out an apartment. If the price is artificially low the agent will prefer childless/petless adults to avoid noise or damage to his property. In other words, the specific regime can lead to differences in both what kind of investments are undertaken, and who ends up using an asset. This difference is said to be causal in that the regime is sufficient condition for the emergence of some phenomenon. Indeed a prominent explanation for the rise in productivity since ancient times is the shift from common property to private property. <sup>13</sup>

Economists reasons of the effects of transition from common to private ownership can be broken down into three subcategories. The most common argument for the creation of private property is rent dissipation: since no agent owns the resource before an action is taken, the agents engage in an unproductive race to capture the resource before other agents. The 'unproductiveness' of this race is due to the fact that the asset is scarce and renewable. If the asset was renewable but not scarce, then there would be enough for it regardless of how much consumed. If it was scarce and not renewable then the early consumption does not harm its quantity. The second reason is that there are high transaction costs (this notion is explained in section 0.2.1) to enforcement in a commune. Finally the third is the incentive to work that is diminished. <sup>14</sup>

Much of economics treats law as merely an instrument to utility maximization. The distinctions of each branch of law (tort, contract, family, property, etc.) create their own rules that individually and independently increase utility and efficiency. Discussion of property rights can be broken down into four distinct questions. 1) What are the assets that property rights protect? 2) From who is the property protected? 3) What is the content of property protection? 4) What is the enforcement mechanism by which property is to be protected? The economics way of answering these questions generally leans on two kinds of efficiency:

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<sup>13</sup>see [Anderson and Hill \(1983\)](#) and [North and Thomas \(1973\)](#)

<sup>14</sup>Works on rent dissipation: [Dasgupta and Heal \(1979\)](#) [Gordon \(1954\)](#) [Cheung \(1970\)](#) [Schaefer \(1957\)](#) [Scott \(1955\)](#) [Clark \(1990\)](#) Works on transaction costs: [Coase \(1960\)](#) [Demsetz \(1983\)](#). For the incentive to work see: [North \(1990\)](#)



allocative efficiency and investment efficiency. Allocative efficiency means either to allocate the asset to the agent who values it the most or the agent who has the lowest cost to operate it. Both of these notions require the static concept of value. Value in economics is usually broken down into two components, market value and subjective value. These notions are important in that the whole framework of analyzing property rights leans on their interaction. I quickly analyze some cases of how these notions interact. One of the achievements of economics is the deduction of the market value of an asset by the description of the subjective value. Note that a positive market value does not imply that exchange occurs; indeed subjective value is the key to the whole framework of the optimal allocation of property rights. When discussing numerous independent assets the above logic holds, however when the utility of assets is not independent then additional notions enter into the framework. Independence of assets simply means that each asset is to be valued separately and does not depend on whether other assets are acquired with them.

### **Identical and strictly positive subjective value for all agents**

If an asset has an identical positive value for all agents then it has a positive market value but no exchange occurs.

### **Identical and null value for all agents**

If an asset has zero subjective value for all agents, then it also has zero market value because nobody is willing to buy it.

### **Identical and negative value for all agents**

Then the market value is negative and the allocation of property rights just means, "who will be targeted to receive this asset". In such a case, there is a demand for abandonment or destruction. The decision whether to force the ownership of the asset on someone should depend on whether the asset is best left abandoned or destroyed, if the optimal use of the asset is its destruction then ownership should be forced, if its optimal use is abandonment then no property right is necessary. Of course there may also be a situation where one requires someone to own something without giving that person the right to abandon or destroy.

### **Variable and weakly positive value for all agents**

Suppose now that we introduce variance into the mix. If agents have differential positive value for the asset, then a positive market value exists and an exchange occurs unless the highest value user is one who is allocated the property.

### **Variable and weakly negative value for all agents**

Hot potato: Similarly if all agents have a differential negative value of the good then there is still a market value to the good unless the highest value user owns it. This is because if anyone other than the highest value user owns the good, they would be willing to pay the highest value user to own it. In this case they would consider the lowest cost alternative between subsidizing the highest value user to own it versus destroying it or abandoning it.

### **Variable, positive and negative value**

Some difficulty arises when we mix the cases. For instance if the distribution of subjective value includes both positive and negative values, then clearly if transaction costs are zero, then there will occur a trade if the good is given to anyone but the highest value user.

## **0.2.1 Coasian paradigm**

A *transaction cost* can be defined as the cost of accessing the market value. So by definition, if an agent owns an item at equilibrium and has a lower valuation of it than the market value of the object, this must be because of the transaction cost. In other words the broad category of transaction costs can include psychological, institutional, physical factors etc, anything that prevents an entailment of the form "If this individual owns it then this individual has the highest value". From the point of view of efficiency (to be defined in the next paragraph), the question of making destruction or abandonment illegal becomes relatively more important as transaction costs increase due to the risk of over-destruction or over-abandonment. A liquidity constraint (also known as a *pecuniary externality*) is also a sort of transaction cost: if agents cannot buy a good which has a market value lower than their subjective value then we have a reason for allocational inefficiency. Similarly, if an agent does not know the market price or is ethically against using the market mechanism, these are both types of transaction costs. There are many things in society which are either naturally or legally inalienable (kidneys, votes, future labor, historically important assets, etc), and to the extent that inalienable endowments exist, these can be interpreted as exorbitantly high transaction

costs. From the framework examined above, a transaction cost is usually a function of a lack of higher order rights, one can only transact on the rights they have.

The notion of efficiency in economics has a static and a dynamic dimension. Static efficiency is usually termed *allocationally* efficient. This simply means that the set of actions which maximize sum of agents values is taken, this kind of efficiency is also known as Kador Hicks. When the question being posed is related to ownership of an asset, allocational efficiency simply means that an asset is owned by its highest subjective value user. Notice that this contrasts with the much stricter notion of Pareto efficiency which says that a state is efficient if it is not possible to improve someone's situation without reducing someone else's value.

The dynamic notion of efficiency used in economics is *investment* efficiency. This conception brings attention to growth. The idea behind investment efficiency is that the allocation that results will lead to the highest amount of growth and hence eventually, the highest long run payoff. The two notions are sometimes in conflict in that static efficiency is not necessarily good for growth. The interaction between these two ultimately depends on the discount rates of agents. When the agents don't discount the future and reason intergenerationally, the two are perfectly compatible.

The Coase theorem is fundamentally about static efficiency. The theorem states that if transaction costs are zero, the result of the market interactions is allocationally efficient. This can also be interpreted from an action standpoint to say that agents will interact among themselves in such a way to maximize the total payoffs. If on the other hand there are non-zero transaction costs we can only discuss constrained efficiency in the sense "of those who entered the market, the highest subjective value will receive it". There has been a reading of Coase where a zero transaction cost world implies no firms; this reading, however, depends on not having gains from specialization<sup>15</sup>.

The Coase theorem is of direct relevance to most analysis of externalities. Externality is often a poorly defined concept<sup>16</sup>. One temptation is to define it as effects on non-consenting parties, however this is too large of a conception since competition is all about negative externalities between firms. Instead, externalities are best defined as effects on non-consenting parties *which do not pass through the market mechanism*. The theorem was initially framed with externalities in mind, perhaps its most counter-intuitive result is that it implies that externalities become internalized if there are sufficiently low transaction costs, said otherwise, agents individual private costs will be equal to the social cost.

The theorem also describes the kind of effects the legal system can have. Take a problem

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<sup>15</sup>See [Demsetz \(2011\)](#)

<sup>16</sup>for details about why it is a poorly defined concept see [Cheung \(1970\)](#)

situation where there is an infringer and the owner of the property that is being infringed. If the owner has full claim rights (veto capacity) on his property and others can only use it with his permission, this is called a property rule. If on the other hand there is a fixed or court determined cost associated with infringement this is called liability rule. The theorem states that when transaction costs are sufficiently low, both liability and property rules will result in an allocationally efficient outcome. This has sprouted a rich literature on choosing the legal rules as a function of transaction costs.<sup>17</sup> For instance, the liability rule may be preferred due to: the holdout problem<sup>18</sup>; free riders; accident situations; if the infringer is better informed; if the infringer has less liquidity; etc. Alternatively, if transaction costs are deemed to be sufficiently low, the legal rules can be chosen for other criteria than allocational efficiency, for example, distributional considerations.

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<sup>17</sup>Theoretical: Calabresi (1972) Empirical: Kaplow (1995)

<sup>18</sup>The holdout problem is distinct from the holdup problem in that the holdout means that agents will not reveal their true value, whilst the holdup problem means that no investment will take place

### 0.3 The Dynamic creation of property rights

Once we introduce time into the picture a few things become more complicated. Time may create new property in one of two ways, either because the actual material goods have increased, or because new information has led to an increase in property (for example, the discovery of existing assets). New property creates questions about how to allocate property that previously had no owner. In other words, time gives rise to questions about property allocation before it exists, *ex-ante*, and whether property is allocated after it exists, *ex-post*.

There are ex-ante rules one could adopt that solve property future allocation problems. For instance, if all surface area is fully allocated, then new physical property will just be allocated to whoever owns the surface on which it is discovered. Full geographical rights in this manner give rise to questions of volume rights, such as air or underground; the shape of the rights expansion has different implications. If land property expands into the sky via a cone shape, reverse cone or rectangle this can determine operating costs of underground facilities or the cost of flying overhead due to the allocation of air rights to either too multiple agents, no agents, single agents. The relationships are summarized in table 1.

	<b>Vertical Rights</b>	<b>Cone rights</b>	<b>Reverse Cone rights</b>
<b>Air Space</b>	Unallocated	Unallocated	Full allocation
<b>Underground</b>	Overlapping	Full allocation	Overlapping

Table 1: Results from volume rights law

Ex-ante fully allocating surface area rights is difficult, mainly because agents are often not interested in allocating property before it has a value. Instead, property rights emerge naturally as the value of assets increases, as there will be demand to create rights <sup>19</sup>. An ex-ante regime of property can apply to both physical and biological property. For instance, if a piece of land is found to contain oil, it would go to its owner. Similarly for organisms, if a pet is owned, one usually owns its offspring.

Consider an asset that creates new assets and is owned ex ante. There are three cases to consider: 1)the case where creation is independent of use; 2)the case where the creation is increasing in use; 3)the case where creation is decreasing in use. We consider each in turn. If the production of future assets is independent of usage then the owner need only consider the demand side of the market. If on the other hand the production of future assets increases with use, the tendency will be for use to be maximized. Finally, if the generation of future assets decreases with use, then the optimal extraction rate will depend on the discount rate

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<sup>19</sup>for details about the emergence of property rights see [Alchian \(1973\)](#)

of the owner. In the third case the concepts of allocational and investment efficiency depend on the discount rate, which naturally leads to the question: Whose discount matter should be used? Presumably the owner's discount rate will always play a role but if she intends to sell the asset to others, then the owner will also take into account the discount rate of others. Once the interaction between the agents is well specified it is possible to claim that the owner will have the incentive to harvest at the optimal rate. For the case of fisheries this just means the owner will tend to calculate the optimal rate of fishing per period, if the demand for fish is more or less constant per period, this harvest rate will correspond to the long run maximum number of fish.

The cost of ex-ante allocation is an important factor in determining the regime that will be adopted. For animals there are times when ex-ante allocation can be cheap (branding, collars, microchips, etc), and times when it can be expensive (fish, birds, etc). If it is difficult to create ex-ante allocation then there will be effects which depend on the ex-post regime adopted.

The basic problem of dynamic property rights is conditionality. That is, property that is only allocated conditional on some effort. A potential normative role for the economist is to judge if the effort in question is desirable. It seems clear that if the effort is investment in some socially desirable good, then the effect of the conditionality is positive. However conditionality can also cause negative effects.

Consider the case where elk move between properties. The ex-ante ownership of the animals would result in Coasian bargaining. If the elk owner has a sufficiently positive value in owning the elk a few things can occur. If the elk trespass has a low cost to the neighbor, then the free roam will be accepted, perhaps with payment to the neighbor. If the trespassing cost to the neighbor is large, then the resulting outcome may be to build a fence. If both the neighbor and the owner benefit greatly from the presence of the elk, then they may even jointly undertake investments to improve the quality of life or reproduction rate of the elk, perhaps in the form of a sanctuary. Notice that the result is dependent on the cost/benefit structure stemming from the agents, and the specific environment they find themselves in.

If it is costly to create an ex-ante allocation on animals, a number of ex-post conditional property regimes may arise, each with its own effects. If the animals are only owned conditionally on being on the land, this creates incentives for fencing as long as the wild animal has a positive subjective or market value. If the animal is only owned when killed, then this creates an incentive to kill it. If land is lost (re-possession) conditionally on having deer on it, then this creates an incentive to evict or hide the deer. In other words, the conditionality of property rights can have a plethora of effects. Notice that the fence may emerge in both

the ex-ante ownership and the conditional "on land" regime, however in the latter case, the presence of the fence is not necessarily efficient (in Kaldor Hicks' sense).

In the case of public property rights often the conditionality is on geography. For instance, if some property's fruits are shared based on some geographical specification, this incentivizes entering the geographical area in question. In a sense the only way to sell one's share in the property is to move. This often has the effect of involuntary dilution of one's share due to new entrants. In the case of private property a similar dilution may occur in the case of stock ownership, but it is usually for an associated sum with the idea of increasing the value of the shares held by investors by more than their dilution.

When production plays a role, property is best attributed to the people who are responsible for the production; this could be because they have knowledge of how to use it, or because they have some characteristics, such as risk bearing ability, which would create higher productivity.

Conditionality can shed new lights on the normative theories of property rights. For instance, Locke's theory that something is owned conditionally on mixing one's labor with it, whilst a moral theory, from the point of view of economics, has descriptive content in the sense that such a property rights paradigm incentivizes people to combine their labor with objects that can be appropriated. From the value-maximization point of view this is not necessarily efficient relative to ex-ante ownership because this creates an over-incentive for labor instead of output. However in a world where there is too much uncertainty about the output of investments and a general unforeseeability, a simple heuristic in the form of labor mixing may be better than no heuristic.

A specific case of this conditionality is labor. Firms decide to reward employees based on their productivity. The implicit assumption being that agents put in effort as a function of the compensation that will be made conditional on that effort. For instance, if there is a set of agents, a set of assets, and each agent can only work on a single asset, then it is simple to show that more production will be achieved in the case where agents own a higher fraction of the assets they work on than if their ownership was more distributed. This basic logic has led to the development of the modern theory of the firm due to Hart and Moore (more on this below).

The idea that property is granted conditional on some actions is a simple way to frame numerous concepts in economics. The questions of allocation and investment efficiencies are both dependent on the conditions under which new property is distributed. The *tragedy of the commons* is a notion where, due to common ownership of a good, agents over-use that good. This incentive to "over-use" emerges naturally because the deterioration of the good

from overusing is shared among all owners, whilst the benefits from use are focused.

A classic example of the tragedy of the commons is over-fishing. The issue with fishing is generally that all agents have the privilege of fishing the fish without actually owning them. The specific conditionality is that the fish are *only owned once fished* out of the water, which creates an incentive to over-fish. The tragedy of the commons appears when rights are granted conditionally, the severity of the tragedy increasing as the rights granted increase. To illustrate we need only note that if agents possess the right to eat a fish conditionally on fishing it, then only the agents whose subjective value is greater than their cost will fish,. In this scenario over-fishing will occur purely as a function of population. If on the other hand higher order rights are given, then agents will be incentivized to fish until the market value equals their cost, this is strictly more demand than the first order rights case. In other words giving higher order values to the agents will incentivize them to not only fish for themselves but also for the rest of the community. Note however that this outcome may not be efficient in the Kaldor Hicks sense since some agents may have a lower cost of fishing. In general we may say that if there are full unconditional property rights, and the transaction costs are low, the allocational and efficient outcomes are achieved. On the other hand conditional property rights give rise to overuse(relative to the unconditional case) and no property rights gives rise to under usage.

So far our discussion has assumed that numerous effort levels are possible but the conditionality to earn property is binary, that is if the agent puts in more than some critical threshold he gets the property. However the same reasoning holds for more continuous assets such as monetary compensation. It is possible to analyze the connection between the effort level (input) and distribution of goods (output). In the incomplete contracting approach, the new property is created conditional on some ex-ante effort, but distributed as a function of ex-post bargaining power. While in the static Coasian view, the ex-post distribution does not affect decisions, in an incomplete contract world the ex-post distribution can change decisions. This basic tension motivates some general results on private property from the point of view of incomplete contracts.

### 0.3.1 Incomplete contracting

The general motivation for property rights in the incomplete contract literature is that property rights allow for investments to be undertaken before a contract is signed. Why is there a need to give negotiating power ex-post? Because ex-post, the other party has no reason to compensate for more than the value added to the transaction. In other words,



other parties have no need to compensate agents for their fixed costs which were undertaken before the contract was signed.

Why can't contracting be done ex-ante? There are two commonly given reasons: either contracting ex-ante is not profitable, or because the future states cannot be described (Hart, 1999). The foundations of incomplete contracting have often been criticized on the ground that firms can just contract on outcomes instead of states, and this can be equivalent to the first best contracts<sup>20</sup>. This contractual incompleteness is part of a setup for a larger problem in economics, the *hold-up* problem, which says that if agents cannot use their sunk costs in the first period to negotiate in the second period, they will always under-invest.

The justifications often go very far to explain something that can have quite a common sense foundation. Why can't agents contract ex-ante? A simple answer could be that the agents are not agents ex-ante. For instance, if we imagine an individual throughout her life, some of her choices will be decided by those around her, either because of the cultural atmosphere or because they are not capable of making decisions. For example, in a family structure, a parent may wish to invest for their child but they cannot contract long term on the child's behalf (this would be a form of slavery). Instead, the parents can optimize ex-ante investments for their children without committing them to long term contracts.

Incomplete contracts imply a number of things about the theory of the firm. The theory of the firm is often framed as being about whether to outsource or in-source production. The problem with in-sourcing is that agents will be less motivated to put in effort because the benefits of the effort will be split; the problem with outsourcing is that the agents' ex-ante investments cannot be recovered later on. If we imagine an employee within a firm that is choosing between projects which bring in profits, she will prefer projects where the firm can observe that she is the source of the profits. If on the other hand she was independent, she would instead choose projects which would maximize her profits. This reasoning has been used by economists to explain why innovation often occurs in small firms rather than large ones.<sup>21</sup>

The mechanics of the incomplete contracting model are simple. Agents may make investments that are only useful if used with something else. For example an agent may learn to code but not have a computer. In a first period, firms can undertake ex-ante unobservable investments. In the later period they can try to sign a contract with some other party who owns the asset which makes the investment useful. The problem is that the investment has already been undertaken by the time they are negotiating with the other party. The other

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<sup>20</sup>see Maskin (2002) and Maskin (1999a)

<sup>21</sup>see Holmstrom (1989)

party has no reason to compensate them based on their past investment; this then leads to firms underinvesting. If there is only one firm that can undertake the investment, then the solution is simple: that firm needs only to buy ex-ante the asset it needs from the other party and then invests and reaps the profit on its own.

However if both firms can undertake investments, there is larger issue. The party that does not own the asset will under-invest.<sup>22</sup> The solution to this larger problem is algorithmic in nature and requires more time periods: Firm 1, is given the asset, and firm 2 is given the right to buy the asset at a certain price<sup>23</sup>. Firm 1 has the incentive to invest because otherwise the second firm will not buy it and firm two has the incentive to invest because otherwise it will not recuperate the its purchase price.

This same logic can be interpreted through re-negotiation, instead of buying the asset that has been worked on, the parties' just bargain after the investment, but all the bargaining power has to be given to the party that invested. This sequential logic has limitations if there is uncertainty about what the optimum is.<sup>24</sup> Note that the ownership of the asset itself is not the causal factor. What is important is that a firm that is not needed does not have veto power.

More generally, the model has a few conclusions: 1) If only a single agent can make asset specific investments, then allocative efficiency says that that agent should own all the assets; 2) All assets should be controlled by a single person at a time(not necessarily the same agent); 3) No more than a single agent should have veto power over an asset;<sup>25</sup> An explicit assumption of this model is that assets only have value on the ultimate coalition that ends up using them. While this may be true in physical property, it is probably false for intellectual property.

Conceptually we can imagine the effort as flowing towards three different components. The three components are, either the effort flow directly into the agent putting in the effort(human capital), either into an asset(physical capital), or into another party. The question of private property has to do with how many parties should have veto power over the use of the asset, and how should the veto power be distributed. In general, the presence of the veto power is a disruptive force so it is best to give it to the party whose non-participation would already be most disruptive or whose participation is already necessary.<sup>26</sup>

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<sup>22</sup>There is no notion of equal ownership possible because the asset is indivisible.

<sup>23</sup>for a first best this price should be the value of the asset after the second firm has also invested

<sup>24</sup>for designing the option contract see, [Nöldeke \(1998\)](#), for sequential investments with complementary assets see, [Zhang \(2014\)](#),[Bessen \(2009\)](#) , for the breakdown of conditional contracts see, [Maskin \(1999b\)](#)

<sup>25</sup>This is found in [Hart \(1990\)](#)

<sup>26</sup>the original model was intended for human capital only, created by [Hart \(1990\)](#) which builds on the work of [Grossman \(1986\)](#)

Specifically if the effort(s) flows directly into either the agent(s) putting in the effort or directly into the asset, it is best to minimize veto power. When the effort flows directly into its own agent, then it is best if no veto power exists at all. If on the other hand the effort flows directly into the asset, then it is best if the asset is given to a single agent, the agent who is most productive with the asset.<sup>27</sup> On the other hand if effort flows into other agent's(perhaps we can imagine agent's funding each other's education) then it is no longer optimal to minimize veto. If only one agent exerts the effort then he should own the asset. If both agents exert effort that flow into the other, then both agents should have veto power.<sup>28</sup>

Some additional results from the incomplete contracts literature are highlighted below: Agents can also endogenously decide between them who will own the asset. This will depend on their relative marginal contributions to the asset and their ex-post bargaining power, or if there are liquidity constraints, they may prefer a third party to own the asset; The framework can also be used to discuss the narrow incentives of the firm that will potentially integrate as opposed to the broader incentives of the firm being bought over in a scientific vs commercial payoff context; In the context of innovation, the incomplete contracts framework implies that for ex-ante contracts to be less restrictive, a larger amount of liability is required, to weed out bad inventors; If there is also asymmetric information between the two parties, it can also be shown that joint ownership with veto power is optimal, this induces parties to share their information;<sup>29</sup>

The setup of veto power given to unnecessary members is especially suited to analyzing intellectual property. The kind of situation described, where a party is in a coalition for the sole purpose that they have an asset is, in fact, the norm in intellectual property regimes. The contracts framework is interesting because the value created between parties in the original work is not the price of the good but the value of the transaction. To render this point clear, suppose there is only one coalition using intellectual capital, now a different coalition without any intersecting members may adopt this good without decreasing the value of the first coalition.

The framework is interesting because it does not identify the source of the value of a transaction but instead merely states the necessary conditions for the value to be created. Notice that the notion of value being used here is not profits but subjective value. That is, while it is true that being the second firm to use an intellectual asset may mean a firm reaps less

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<sup>27</sup>For efforts flowing to assets, see [Schmitz \(2013\)](#), [Gattai \(2016\)](#), [Schmitz \(2017\)](#).

<sup>28</sup>see [Hamada \(2011\)](#)

<sup>29</sup>see respectively, [Aghion \(1994\)](#),[\(Lerner and Malmendier, 2010\)](#),[\(Anton, 1994\)](#), [\(Rosenkranz and Schmitz, 1999\)](#)

profits, in the subjective value sense this is not correct. That is, it is not because one agent figured out how to use his assets better first that the second agent will be less happy about discovering the same method. The framework of Anton (1994) use the profit notion of value and not the subjective notion of value because they assume that as knowledge leaks from the intellectual asset occur, eventually the asset becomes worthless.

Depreciation in use is the most natural way to conceptualize the quantitative differences between physical and intellectual capital in the subjective value paradigm. In a model where assets are used sequentially in different transactions, one can articulate the difference between physical capital and intellectual capital. Transactions that occur later and only use a physical asset will lose value due to the wearing out of the asset, whilst transactions that use intellectual capital do not lose value with use. In a value as profit model, intellectual property would also depreciate because either knowledge leaks out and becomes less valuable, but in a subjective value framework, this same logic does not apply.

## 0.4 Intellectual Property

The term "intellectual property" encompasses three notions legal rights Patents, Copyright and Trademarks. Patent's generally being protection of non-digital technologies, copyright being the protection of digital technologies, and trademarks being protection of a specific image or logo with which companies identify themselves. When economists discuss intellectual property they usually only encompass patents and copyright. The presence of trademarks is uncontroversially considered as a positive in economics, it simply the ability for consumers to identify a specific producer, from the point of view of the producer, it is the ability to monetize reputation.

Intellectual property is subject to a unique asymmetry in legal enforcement. In a normal property trespassing dispute, if the trespasser is found to be in the right without mention of his idiosyncratic attributes or circumstances this would create a general free access to the property, the total value of this free access would be naturally bounded due to the scarcity of the property, there can only be so many resources to extract. On the other hand, if the asset is an intellectual asset, if the court denies the intellectual property, the potential user base is virtually boundless due to the non-degradability of an idea. In other words there is a structural asymmetry in patent law, where patent validations are private goods and patent negotiations are public goods. This means that unless the public goods problem is overcome the regime may consistently not take into account the proper costs and benefits of intellectual property.

The general goal of intellectual property is to increase innovation. Whilst many believe that the purpose of the intellectual property system is to protect inventors, the economics approach attempts to follow the legal imperative, which is that the system is about incentives. In other words, in theory, if it can be shown empirically that intellectual property law inhibits innovation, the legal system should theoretically abolish the rights altogether. Much of the problem with this stance is that the legal system imposes a system and asks for evidence that it is not necessary, when in most traditions of common law, the approach is the opposite, the legal system will intervene if there is evidence to support a certain claim. This implies that there is a shift in the burden of evidence, whilst most common law starts with a problem and gives a solution to it, the intellectual property rights approach gives a solution and then asks for evidence that the problem does not exist.

Economists often group patents and copyrights because the arguments around market structure that are used to justify both these kinds of rights are essentially identical. To balance incentives/dead-weight loss of intellectual property, economists focus on the ratio of the cost of discovery to the cost of copying. If the cost of development is immense but so is the cost of copying, then there is no need for IP since an entrant cannot come in to reap the profits. Similarly the case where the cost of copying and the cost of innovating are both low also implies there is little need for protection.

The justification for intellectual property has been changing ever since its inception but they can be separated into two categories, ex-ante and ex-post. Ex-ante reasons, that is, to justify what would occur by the presence of protection *before* an asset exists are about creating the incentives so that the asset/innovation will be created. Ex-post reasons on the other hand are justifications for protection after the asset exists. Ex-post justifications are about ensuring that the asset is optimally used, in both an investment efficiency sense and an allocational efficiency sense.<sup>30</sup>

A rather serious issue of ex-post enforcement of intellectual property rights is that firms have an incentive to push their product. The number of reasons or functions that agents may have to purchase a product can also be important. If the reasons they have to purchase a product are wide then it is ambiguous what giving each firm a monopoly on a single product can do, perhaps one possibility is that firms will simply differentiate to specialize into different functions. On the other hand if the product has relatively few dimensions on which agents wish to evaluate it, such as a medical drug where the relevant evaluative dimension is something of the form 'expected health as a function of time', in such a case the product pushing can be unambiguously negative, a firm may push an inferior product

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<sup>30</sup>for a discussion of ex-ante versus ex-post justifications [Lemley \(2004\)](#)

because it is unable to sell the superior product. For this to occur agents need simply to not be perfectly informed on products. A similar effect may occur for future innovations, where inferior technologies will be researched because vertical control is guaranteed and no hold-up problem will occur.

The origin of copyright in England is particularly interesting because it gave rise to the arguments in favor of intellectual property. Stationers' Company, a publishing house, petitioned parliament for the first copyright laws in 1643 making a number of arguments, the most economically important being: 1) Books are a luxury good and demand for it is elastic, therefore it cannot harm the public; 2) A monopoly would create a safer environment for sales and increase both the number of books and decrease their sales; 3) Would reward the book authors; After almost two centuries of copyright it was noticed that there was a divergence between American book prices and English book prices, so the arguments in parliament changed. The new emphasis was on emphasizing how poorly publishers could predict the sales of books. The poor ability to forecast future sales implied a need for higher prices so that the publishers could recuperate their costs. Interestingly this argument, *prima facie*, does not justify the divergence in prices between US and UK prices, and as Plant points out, the firms likely understated their ability to predict sales. <sup>31</sup>

The dead-weight loss that occurs due to intellectual monopoly is easy to illustrate. A book publisher can produce any number of books and there may be demand for books up to the cost of producing the good. The producer of books does not in fact have the incentive to produce books until the marginal cost because it would reduce the price for all the books sold and hence would choose to produce until it maximized its profits. The loss in welfare in the state with the fewer books at higher price relative to the state with more books at lower price is what economists call dead-weight loss. There are market reactions that reduce the dead-weight loss but this comes at the expense of the firms profits, for instance if a book can be read and then has no value for an individual and that individual can re-sell it, then this represents competition which can cause a price decrease, in theory this can even cause a price decrease down to the cost of re-selling it. However the dead-weight loss in itself may not be a large problem if the goods are durable(as intellectual assets usually are), this is because a firm may wish to take the monopoly price at each period, after selling to some consumers during each period. <sup>32</sup>

The alternatives to intellectual property can also be separated into ex-ante or ex-post. Innovation can be undertaken by seeking funds before it is undertaken. Patronage was historically

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<sup>31</sup>For details about the history see [Plant \(1934b\)](#)

<sup>32</sup>the Coase conjecture essentially states that the demand distribution would get truncated every period until it approached the marginal cost of production

the main source of funding for music, architecture, books, etc, whether this be patronage for pleasure or for profit<sup>33</sup>. In the modern world, in addition to patronage there is equity finance, debt financing or crowd-sourcing (examples are Kickstarter, gofundme, Patreon, etc). The advantage of patronage and crowd-sourcing is that they do not rely on a future stream of revenues since the funding arrives directly from the consumer. Ex-post financing is often what the economic arguments are targeting as infeasible because once an innovation exists, other agents can also use it. Ex post financing usually means services or products that use the innovation in some way.<sup>34</sup>

Ex-post financing is often what the pro-IP economics arguments are targeting as unrealistic because once an innovation exists other agents will dissipate value. Ex-post financing usually means that agents can monetize on the intellectual property by the use of services or products which capitalize on it. The assumption that this is not a feasible option usually has a number of assumptions: The assumption that the discovery will spread fast enough to be quickly depreciated; there is no reputational mechanism at work, firms cannot use the fact of their discovery as a signal; firms who developed the innovation did not also develop some other expertise that gives them an edge;<sup>35</sup>

### 0.4.1 Assumptions of intellectual property

There are two fundamental assumptions that underlie the theoretical justification for intellectual property; the first of these assumptions is foresightedness. Perhaps the most commonly ignored in the economics literature is the former. Since the argument for intellectual property is that after the innovation exists, there will be no rents possible on it, agents won't invest to make this innovation occur. This fundamentally implies that innovation is directed, that is, that there is an agent who will invest based on his expected future payoff.

There are alternatives to innovation through investing in foresightedly profitable projects. Why might an agent take on a costly project that is not foreseeably profitable? One simple answer is that the agent is a hobbyist, that is, someone who enjoys the prospect of discovery. There is also perhaps an inbuilt assumption in the question, that is, do agents undertake on projects that have known outcomes? Clearly the answer is no, whilst there are areas where the agents know the result they want, they do not know which method the given outcome will occur. The behavior of agents can be said to be determined by two forces, incentives

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<sup>33</sup>For an analysis of patronage in 19th century Austria see [Carletti \(2013\)](#)

<sup>34</sup>this has a number of assumptions: perfect information, no reputational mechanism, no developed expertise, etc

<sup>35</sup>For some historical evidence of reputation playing a role in the development of new seeds in the 19th century see, [Charnley \(2013\)](#)



and evolutionary selection, which is related to the deductive versus inductive dichotomy. For instance if firms that tinkered were more likely to survive than firms which didn't (regardless of their reasons for doing so) then the long run equilibrium will include firms that tinkered.<sup>36</sup> It is easy to see how this is relevant in real markets, a father passing down a practice to his kin, without knowing why the practice works is just such an example.

What force matters if the market environment is fundamentally unknowable and irreducible? If there is a wide array of actions and firms choose randomly among them then the result depends on the kind of stochastic process associated with each action. Clearly if some action has the highest mean and lowest variance then in the long run only firms which choose that action will survive [Alchian \(1950\)](#). If on the other hand there are actions with higher means and higher variances it may be optimal for firms to choose as a function of their own characteristics such as size. It may also be that mixing between actions will yield the optimal growth to variance trade-off. This kind of analysis implies that the behavior of firms in the long run will not only be of firms which earn the maximum amount of profits but there will also be strategies where firms which simply make positive profits.

It is also important to look at competition between markets, if one market grows consistently slower than another this will imply that the slower growth market eventually becomes trivially small. This kind of inter-market competition can imply that in equilibrium only markets which have a sufficiently high growth rates will emerge, which in turn may imply evolutionary pressure towards *R&D* investments.

The view of economics as agents with heuristics has more traction than first appears if one looks at the frequency of occurrence of serendipitous discoveries. A large tome could be concocted with a list of breakthroughs that is not directed but which are accidentally stumbled upon. Specifically for medicine, the list of drugs that were discovered accidentally is large: *Periwinkle*, *Platinum*, *Aspirin*, *Thalidomide*, *Librium*, *Valium*, *Thorazine*, etc. Similarly the *Jet Engine* seems to have been developed without a clear sense of the developmental process and with researchers having a very limited background in physics. Even seemingly modern fields such as *Cybernetics* which was formalized by *Wiener* in 1948 was just an ex-post formalization of existing systems. Perhaps most noteworthy is how the processes of development in fields such as architecture caused developments in the structure of mathematics. Financial Economics has its own examples for instance the *Black Scholes Formula* did not seem to have an impact on the prices of options (indeed the makers of the formula famously went bankrupt when trying to exploit their discovery). The general takeaway is that the

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<sup>36</sup>Incentives of course do not solely, depend on agent's ability to predict, if the agents have false beliefs, this may also be sufficient to induce agents, however in such a case, there would be evolutionary pressure against such agents.



ideal of "theory to practice" often is contradicted by evidence, indeed, the practice is often what leads to the theory. <sup>37</sup>

The idea that innovation occurs due to heuristics does not imply that the rate of innovation is policy invariant. Indeed the competitive environment can matter a great deal since for innovation to occur at the evolutionary stable state it should increase the probability of survival of agents who innovate, nevertheless the returns to imitation will be bounded and in equilibrium, innovation will occur. [Winter \(1993\)](#) The consequences of viewing agents as heuristic creatures has widely been exaggerated, with much of micro-economic theory remaining intact, indeed the economic orthodoxy of patents would likely be the main casualty from such a paradigm shift. [Becker \(1962\)](#)

The second fundamental assumption of intellectual property is that being first to market has a very limited effect on profits, or weak first mover advantage. This assumption can seemingly manifest in economic models in one of two ways. The common way is to assume that the structure of the market is such that once an innovation is created at some cost,  $F_1$ , the next person to enter the market can freely use it and pays less than the initial creator to use it,  $F_1 > F_2$  whilst having at least the same revenue as the initial firm,  $R$ . The specific description of this market structure is then  $F_1 > R > F_2$ . That is the revenue of the first firm is between the fixed costs of the first and second entrant. The argument against intellectual property then can take three forms: 1) the interval between the fixed costs is minimal(both firms entering does not affect whether the innovation is undertaken); 2) The revenue of the second firm is lower than its fixed cost(second firm will not enter); 3) The revenue of the first firm is not sufficient(innovation would not have taken place anyway)

Using this second assumption as their baseline, one of the first formalization of the model is due to [Loury \(1979\)](#). The general results are that 1) as the number of firms increases, equilibrium investment decreases. 2) Increasing investment of a single firm decreases investment of all other firms by a smaller amount, entailing that the expected invention date is quicker with less firms. 3) Profits go to zero if technology for innovation is concave only in the limit(number of firms innovating goes to infinity) 4) If technology is convex then profits may go to 0 with finite number of firms. However this kind of model is fundamentally fragile to the cost structure of the firms, for instance if innovation is not a fixed cost but a variable cost through time, [Lee and Wilde \(1980\)](#) show that the equilibrium investment is increasing with the number of firms. Additionally if firms decide when to enter the market, this kind of framework can imply that it is optimal for firms to delay when they invest. <sup>38</sup>

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<sup>37</sup>Medicine: [Meyers \(2007\)](#), Jet engine: [Scranton \(2006\)](#) and Planes: [Meyer \(2013\)](#),Cybernetics: [Mindell \(2002\)](#), Architecture: [Unguru \(1992\)](#)

<sup>38</sup>[Weeds \(2002\)](#). Uses investment under uncertainty framework of [Dixit and Pindyck \(1994\)](#)

Fundamentally, if the assumptions that patents induce innovations are correct, patent length and patent breadth are the key policy tools. In an industry where products are substitutable and where the rate of new innovations is high, it is optimal for policy to focus on patent breadth, that is, to ensure that similar products cannot enter the market. If on the other hand the market structure is such that there are not many new innovations then it may be optimal to focus on patent length. Essentially, the cost of innovating must be repaid, this can be done either by having the profits done early in high amount(breadth) or over time(length). <sup>39</sup>

Even if the two market structure assumptions are true, this does not entail that patents are in fact an optimal policy tool. Even if it is true that a patent will create innovations earlier, the same policy tool may delay later innovations. This is specifically an issue, if the latest innovation is required to innovate to the next stage. That is, if the innovation created from the first stage is a required input for potential innovation in a second stage then follow on innovations will be more delayed by a patent system. <sup>40</sup>

Will a firm that can patent always patent? The general economics view is that firms will not patent either due to the fixed cost of patenting or because they have to disclose information about their invention. The fixed cost from patenting(including the document drafting and the application itself) implies smaller firms may have less of a reason to do so. The information disclosure is related to the broadness of the patent, if the patent is not broad, disclosing how an invention works can be sufficient to help competitors make a competitive product. If a firm chooses not to patent, then specific nuances of the patent system such as "first to file"(European Patent office) or "first to invent"(United States patent and trademark office) can play an important role, for instance, the first to file rule can over-incentivize patenting over secrecy.

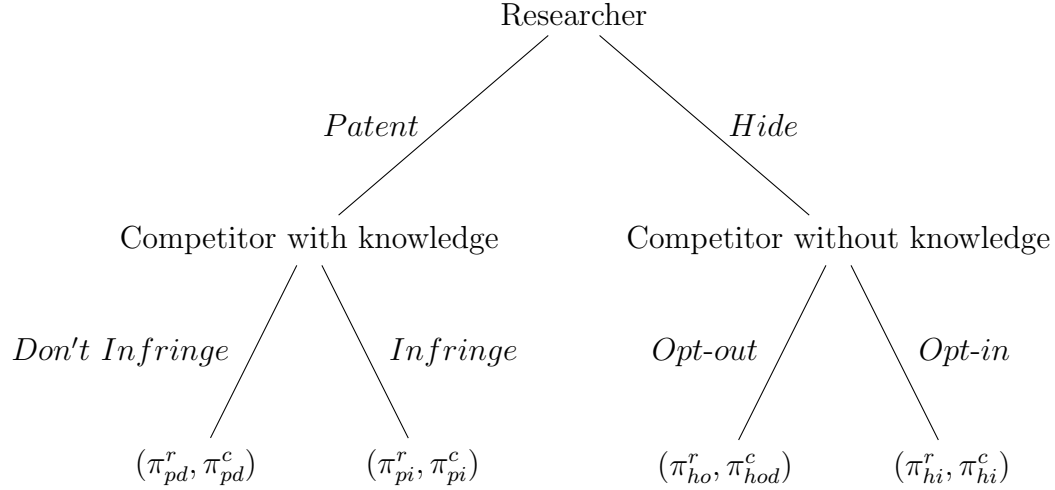
Models that formalize this choice takes the form of a researcher choosing whether to hide or patent. This is in light of a a competitor choosing whether to infringe or not to in the case of patenting and choosing whether to compete even without the knowledge if no patent is present. <sup>41</sup>If there is significant overlap between innovations, the disclosure aspect of patenting may be the most important to avoid wasted effort from re-discoveries of existing technologies Kultti et al. (2007). These practical difficulties have often been used as justifications for the common practice of *reverse settlements* discussed above.

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<sup>39</sup>This is formalized by Takalo et al. (2001)

<sup>40</sup>This was first shown by Bessen (2009) and generalized by Bryan (2017)

<sup>41</sup>for a survey of these models see, Hall et al. (2014), for a model that discusses first to file and first to invent see, Scotchmer (1990)



The choice between patenting and secrecy can depend on the degree to which the innovation is radical. For instance firms will prefer to patent less valuable innovations and keep secret the more valuable ones [Anton \(2004\)](#), this is for the simple reason that not disclosing a radical innovation offers more potential for a larger gap between the secret owner and competitors. However if there are costs to renew the innovation and the degree of innovativeness of the innovation can affect the probability of receiving the patent, the opposite may be true, high quality projects get patented and lower quality projects do not [Mose \(2011\)](#). The decision to patent also depends on the competitive gap between the potential patent owner and potential competitors, if the gap is already large, patenting is attractive. If the degree to which the innovation is radical depends on the firms investment, then weak patents are important but stronger patent protection does not necessarily increase innovation [Kultti et al. \(2006\)](#).

Perhaps another interesting question to ask is whether a company that can use its patent against someone will always do so. Tentatively we may say that there may be a cost to suing but even if that cost is zero the firm may prefer not to sue because the activity in question could be complementary. This kind of market dynamic, where firms willfully choose not to activate their patents, may imply that the system is unnecessary. <sup>42</sup>

## 0.4.2 Mechanism Design

Mechanism design is a natural way to study intellectual property because the system is entirely designed by a legal system instead of emergent. Indeed the concept of a patent race, where firms invest to achieve a certain technological breakthrough and then only the winner will gain the patent, is equivalent to an all pay auction second price auction, a war of

<sup>42</sup>For an example of firms not activating their patents in the development of short message services see [Corrocher \(2013\)](#)

attrition. <sup>43</sup> Mechanism design can also shed some light on when it may be optimal not to assign property rights. If agents have private information in a bilateral transaction, Coasian setting, the agent with the property right will have an incentive to overstate his cost or value because the other party will have no option to go the courts, but when it is unclear who will win in court, parties will have an incentive to tell the truth<sup>44</sup>.

Part of the loss the patent system creates is an allocational efficiency problem. If the highest value user is changing in time, the system has no natural way to not make the current owner reap all the benefits from a transaction with a higher value user. A natural method for reducing this allocational efficiency problem is to use the Georgian scheme and require firms to bid on their own patent every year(a sort of rent), this would establish a price reflecting the current owners value for the patent and would enable the higher value user to purchase the asset.

However the main problem with intellectual property is not the agent who owns the asset but the number of agents who own it, above all, intellectual property is a monopoly, and as a monopoly it can induce deadweight loss. There are a number of tentative solutions to this, making all patents public(free for anyone to use) is one of them but the methods are controversial. Suppose a system was instituted where all patents and future patents were bought over by the government at a fixed price. Whilst this would alleviate the dead-weight loss problem, due to the variety of project values, two issues would arise. One would be that projects worth less than the bought value would be **over-rewarded**. This would naturally create incentives to maximize the number of patents and not maximize the value added of each invention. The second issue is **under-rewarding**, projects which are worth more than the posted price would not be undertaken, this would not be a problem if the cost inventing was below the bought price. The **under-rewarding** issue would entirely disappear if the consent of the patent owner was required, the payments would be bids, but this would also keep the dead-weight loss of those projects in place. <sup>45</sup>

A method of alleviating the issue of overpayment would be to choose prices by creating a price system for each patent. This would be done by allowing firms to bid for each patent<sup>46</sup>. Once the price of the patent is established, the government would then pay that price for the patent. The issue is then, why would a firm bid truthfully if it will not receive the patent? It could perhaps just overbid and then split the surplus with the patent owner, or

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<sup>43</sup>Heidrun C. Hoppe and Baye (2003)

<sup>44</sup>Schmitz (2001)

<sup>45</sup>an interesting historical fact here is that in 18th century France in Lyon, Silk Factory innovation were compensated by the government not only per innovation but also by the dissemination of the idea Foray (2013)

<sup>46</sup>this method was first suggested by Kremer (1998) and was generalized by Weyl (2012)

in the language of game theory, it is not coalition proof. A partial solution to this problem would be that instead of the government buying out the patent deterministically, it would buy it out with some probability, unfortunately this does not alleviate the problem because the firms could still make a positive coalition profit in expectation and if the probability of gaining the asset is low enough, then there would be very little incentive to participate in the mechanism.

Although generally alleviating the monopoly problem is too difficult, it is possible to play with the time dimension of patents to reduce it. To avoid the coalitional problems one could devise a mechanism where a patent owner simply bids on its own patent and depending on the amount of the bid, the patent becomes longer. This mechanism is that different R&D have different productivities and it would result in lower productivity sectors having longer patents and higher productivity sectors shorter patents because if an industry is innovative the value of the patent will quickly depreciate as more innovative products take over, this means that it would be worthwhile to increase the cost per unit of time for less productive sectors relative to more productive sectors so that the mechanism becomes more truth revealing.<sup>47</sup>

What should be the relationship between patent length and the degree of innovation be? For any fixed period patent system, the patent length will incentivize projects which can earn sufficient profits within the period. However the application for patenting may have agents over-applying because it is profitable to gain a patent ex-post on innovations which would not be profitable within the time period. If a patent is granted to these innovations this would be a pure deadweight loss without an incentive effect. To clarify, the potential for a patent cannot be an incentive for projects which would be ex-ante loss making, but once a project exists, perhaps accidentally, an entrepreneur will still wish for a patent. This means that for the granting process to be effective and not incur accidental deadweight loss, it must use a criterion which has to do with how much profit can be attained within a constrained time period. O'Donoghue (1998).<sup>48</sup>

### 0.4.3 Scope and evidence

The spike in interest in intellectual property has occurred due to some attacks by economists arguing that such rights should be weakened. The main vanguard of this attack has been in the works of Dosi et al. (2006), Levine (2008) and Bessen et al. (2008). This attack has incited criticism (Scherer, 2009) along with responses (Boldrin and Levine, 2013). The

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<sup>47</sup>The mechanism was created by Scotchmer (1999) and built upon Cornelli (1999)

<sup>48</sup>this class of models is presented with probabilistic enforcement by Chou (2007)

arguments sometimes use specific historical cases to discuss counterfactuals, perhaps the most radical claim being that James Watts patent on the steam engine delayed the industrial revolution by decades (Levine, 2008) (Nuvolari, 2004) and similar claims have been made made for the development of the plane and the car (Merges and Nelson, 1994). One of the most interesting studies discussed is by Moser (2005) who studies exhibitions at the crystal palace and conclusively shows that relatively few of the inventions were patented (Moser, 2005).<sup>49</sup> It is difficult to evaluate intellectual property as a whole, the evidence seems mixed.<sup>50</sup> Surveys with evidence on innovation seem to imply that it is an ineffective policy tool for the majority of industries, the exception generally being pharmaceuticals and chemicals (Mansfield, 1986) (Levin et al., 1987). This work has since been corroborated in Europe (Arundel and Kabla, 1998) and the US (Cohen et al., 2000).

Take the premise that it is difficult to make sufficient profits from an innovation in some given market as given, it is perceived that some level of reward, say  $x$ , balances the losses from the patent system and the incentives for innovation. Now suppose that through time, the market has expanded so that it is easier to gain large portions of profits in a quicker period of time, if the cost of creating new innovations has remained the same after the market expansion, then the optimal patent system would decrease the reward, presumably by decreasing patent length.<sup>51</sup> The intuitive implication is that as the world becomes more globalized, the requirement for patent protection is decreased because the potential payoffs of projects increase. An empirical measurement that could be relevant is the time from discovery to adoption, as this time decreases, the length of patent would decrease<sup>52</sup>

While it is easy to imagine that policy maker optimizes a social welfare function, in practice, the system itself relies on a bureaucracy. From an institutional point of view, balancing out incentives is crucial, if there is not sufficient incentive to reject bad projects, an issue of over-patenting emerges. This would naturally emerge as the costs of a welfare reducing patent would be diffuse while the benefits would be narrow.<sup>53</sup> The American system in particular has structural features, where court disagreement is discouraged and this creates incentives for patent granting institutions to over-grant patents to avoid appeals, leading to a sort of patent inflation. (Masur, 2011)

A peculiar empirical fact with implications for patents is the practice of reverse settlements. Reverse settlements, the practice of extending patents by paying other firms not to use

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<sup>49</sup>A similar methodology has been applied to US fairs, see Khan (2013)

<sup>50</sup>For evidence that the human genome patent reduced innovation see Williams (2013)

<sup>51</sup>this kind of model is presented in Boldrin and Levine (2009)

<sup>52</sup>For evidence about the drop in adoption time see, Comin et al. (2006)

<sup>53</sup>see Caillaud and Duchêne (2012) for a model with pooling equilibria with good/bad projects and separating equilibria where only good projects are accepted

a technology imply a few things about market structure. The simplest implication is that transaction costs are not very high, so it is possible for firms to strike Coasian bargains. Since these contracts are firm specific, the empirical implication is that smaller firms' don't matter enough to change the profitability of such arrangements. The scope of reverse settlements is unknown, but if these contracts are possible before the creation of an innovation, it may imply that a large segment of the patent system is unnecessary since firms can just negotiate ex-ante with the limited number of firms who could use it. The ability to patent could then be interpreted as an increase of the bargaining power of the first firm (Green, 1995). It is interesting to ponder if firms can foresee whether this bargain will occur, if firms cannot foresee the reverse settlement but undertake the investment anyway this implies that patents over-reward innovations.

An alternative explanation for reverse settlements is that patents are, in practice, probabilistic, and firms don't want to take the risk of the court failing to validate their patent. This probabilistic feature can have two effects, it protects innovations which upon closer scrutiny, would not be protected, and will favor that firms pursue secrecy strategies. <sup>54</sup>.

Perhaps the strangest empirical regularity is the practice of patent pooling. Firms jointly agree to enter a patent coalition and not enforce their patent within the coalition. This kind of structure inevitably leads to a standard for entering the patent pool, entry will be granted only if one has a sufficiently important patent. What is interesting is that this may create incentives for achieving this standard but after entering the pool, there may be little reason to innovate. However even without these dynamic notions, the presence of a patent pool may be welfare reducing if technologies are not complementary. <sup>55</sup>

## 0.5 Contributions in this thesis

### 0.5.1 First chapter

The first chapter is a contribution in pricing a good on which a firm has a monopoly but agents value consuming as a group. The economic terminology for this is simply that the good is a network good, whilst most of economics which models network goods achieves this by assuming economies of scale in the number of products that a platform provides, different mechanics emerge when the network good emerges from the demand side rather than the

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<sup>54</sup>For details about probabilistic enforcement see, Lemley (2005), to see how reverse settlements can signal invalid patents, see Dolin (2011)

<sup>55</sup>see Lerner and Tirole (2004)

supply side. The contribution of the paper is that if a firm has a monopoly on a good, and there exists two ways a product can be sold, a firm will opt into giving a the lower tiered consumers the good freely. The implication is that rights pertaining to intellectual property should be centralized, in the sense that if the firm has the right to exclude other firms, it should also have the right to exclude users, this is contrast to the courts which treat piracy as a criminal offense, implying that the claim rights are not in the hands of a the firm.

### **0.5.2 Second chapter**

The second chapter is a contribution showing that buyouts distort the innovation choices of firms. The model can be interpreted as being within the incomplete contracts literature as firms cannot contract ex-ante. Specifically, if a firm has a choice between a radical and a sequential innovation which both yield the same market payoffs but the sequential one will yield later and the radical one will probabilistically yield earlier, the option to buyout increases incentives towards the sequential technology. In the later part of the chapter we illustrate how this applies with price and quantity competition.

### **0.5.3 Third chapter**

Whilst working on the second chapter this author noticed that firms were preferring earlier payments to later payment without an explicit discount rate, after some tinkering this led to the identification of the cause as coming from the multiplicative dynamic used. This dynamic was later removed from the second chapter and became its own project, the third chapter. Whilst the chapter focuses on agents discounting, the method used abstracts away from any subjectivity in the discount rate, this implies that it could be interpreted as the optimal discount rate of an object instead of an agent. This means that the theory can be directly applied for assets.

The third chapter is about how agents in different circumstances discount future payouts. This chapter is the one with the widest scope as it is a simple alternative way to frame decision theory. Most explanations of discounting rely either on endogenous preferences for discounting, psychological effects or incomplete information. The chapter offers an alternative view which recovers all the traditional methods of discounting(hyperbolic and exponential) by assuming agents have a simple growth decision rules. This kind of decision theory is innovative in that it does not take a descriptive position on an agents knowledge or decision making abilities, but instead just describes the kind of environment the agent is and how that environment can best exploited. This is an example of the kind of heuristics that can



emerge if we consider moving away from frameworks which are too reliant on agents ability to deduce.

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