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Real Options Theory for Lawmaking

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Abstract

The formulation of legal rules is a challenging issue for lawmakers. Trade-offs are inevitable between providing more guidance by specific rules and enlarging the scope by general rules. Using real options theory we show that the degree of precision should be considered a degree of flexibility which increases the value of the text. Thus, we derive a normative principle for a draftsman to choose between rules versus standards and to decide when the law should be enacted. In highly innovating environments, delaying the enactment allows lawmakers to obtain more information. Therefore, the lower the degree of precision of the law, the shorter the delay.

Key words: Lawmaking, uncertainty, flexibility, obsolescence
JEL classification: C61, G12, K00, K40.

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"Ceux qui ont un génie assez étendu pour pouvoir donner des lois à leur nation ou à une autre doivent faire de certaines attentions sur la manière de les former" Montesquieu, 1748, De l'Esprit des Lois, Livre XXIX, Chapitre XVI

1 INTRODUCTION

The design of legal rules is a challenging issue for legislators. The prime aim of these rules is to capture the objective of underlying policies. Limited capacity skills of "producers" and "consumers" of law contravene that aim. Lawmakers are unable to foresee all contingencies and citizens might be misguided by ambiguous rules. As expressed by Landes and Posner (1975:879):

> "the limits of human foresight, the ambiguities of language, and the high cost of legislative deliberation combine to assure that most legislation will be enacted in a seriously incomplete form, with many uncertainty left to be resolved by the courts".

Naturally, these difficulties grow with social and technological changes that generate new uncertainties.

This paper aims to determine how much uncertainty should be left to courts. Lawmakers decide this by choosing the following characteristics of legal rules (Kaplow, 1992, 1999): the degree of precision and whether the content of law should be given at the time of enactment (*rule*) or by the judge (*standard*). A trade-off is inevitable between providing more guidance by specific rules and enlarging the scope by general rules. This choice depends on the *variability of contingencies* and on *the degree of innovation* in the area of the law. The latter relates to the process of obsolescence: times goes by and the rule that was designed for its context at the time of enactment does no longer fit reality. In other words, these characteristics are chosen according to how much information the lawmaker believes he receives.

Variable contingencies tip the scale towards more flexible rules. Lowering specificity in order to increase flexibility bears a cost: benefits in terms of guidance diminish, and uncertainty as regards interpretation rises. Regulation versus *ex post* liability is a classical example where the variability of circumstances influences the choice between rules and standards. Regulation guides firms to stick to a uniform standard of care while *ex post* liability gives the judge the possibility to define the optimal standard of care as a function of each particular case.

Hart (1994:130) highlights this issue:

> "In fact all systems, in different ways, compromise between two social needs: the need for certain rules which can, over great areas of conduct, safely be applied by private individuals to themselves without fresh official guidance or weighing up of social issues, and the need to leave open, for latter settlement by an informed, official choice, issues which can only be properly appreciated and settled when they arise in a concrete case".

A typical example of obsolescence is the creation of the rule on disclosure of information in the financial sector as described by Pistor and Xu (2002a, 2002b, 2003). The underlying policy objective is that firms that trade on the stock exchange should disclose all relevant information to shareholders in order to ensure an efficient functioning of the market. However complex financial products evolve so rapidly that it is not possible to specify all possibilities in statutory law. Consequently, the lawmaker has to compromise between the guidance benefits of precise rules and a lower depreciation rate of general standards. The sensitivity to obsolescence decreases with the "spectrum" of the legal rule. Many other examples can be found in new areas of law, such as genetics, biotechnologies, the internet or music piracy. Law must fit reality, that is it must adapt itself to the uncertain evolution of its environment.

This paper studies how to deal with varying contingencies and obsolescence by using real options theory. In theoretical terms, lawmakers have different options[1]. They can increase the degree of flexibility of a rule. They can also delay promulgation. Finally, they can choose an optimal mix between a delay and the precision of the rule.

The law and economics literature focuses on the relative costs and benefits of rules versus standards. Ehrlich and Posner (1974) develop a static analysis on the precision of legal rules. Precise rules are said to guide courts and the behavior of parties more efficiently before and during the trial, providing them with more complete information. This effect is included by Landes and Posner (1976) in an analysis of the creation of precedents as an investment decision. The set of legal precedents is treated as a stock of information[2] that depreciates when unforeseen contingencies arise. The existence of an optimal stock of legal capital is proven. It is derived from the maximization of the net present value (NPV) of the informational services minus the cost of investment. Future

[1] From this perspective, it is important to note that the paper does not distinguish between primary and secondary lawmaking, i.e. between legislation and regulation.

[2] On the informational value of legal rules, see also Diver (1983), Kaplow (1992, 1995, 1999), Mahoney and Sanchirico (2004).

benefits are implicitly supposed to be certain and general legal capital is assumed to have a lower depreciation rate than specific legal capital[3]. An empirical analysis on citations of laws during litigation shows that general rules tend to depreciate more slowly. Therefore, the greatest benefit of standards can only be perceived by introducing a time dimension: its adaptability to a large set of circumstances. Ehrlich and Posner (1974) further observe that a standard enables the legal outcome to change over time when the economic and technological environment changes. The counterpart of these advantages is that precision is costly because courts have to collect a lot of information before formulating and applying rules.

To assess the value of law, one limit of the NPV criterion used by Landes and Posner (1976) is that it does not permit to take into account the uncertainty which characterizes the evolution of the value of the contents of a legal statement. A "content" is defined here as an interpretation, a meaning of the statement (Kaplow, 1992). A standard such as adopting "reasonable care" has multiple contents determined by *ex post* contingencies, while a rule generally has only one. The value of a content varies with the disparities of situations.

Very recently, the method of pricing legal options has been applied to legal frameworks (Ayres, 2005, Bar-Gill, 2005, Grundfest and Huang, 2004) in order to capture uncertainty from the agents' point of view (litigants, potential offenders). Parisi, Fon and Ghei (2004) took the point of view of lawmakers and proposed a model of investment under uncertainty applied to the timing of the decision to invest in law. They show that there is a value to waiting in lawmaking.

However, the question of flexibility on the choice of the *ex post* legal content has not been analyzed using the real options framework. The specificity of our approach lies in the use of real options to analyze the characteristics of legal rules. In a first step we evaluate flexibility regarding the ex post choice of content, and a decision making rule is derived to choose between a rule as opposed to a standard. In a second step, the flexibility of the timing of enacting the rule is evaluated and a decision rule for the lawmaker to choose when to enact a law is derived as a function its degree of precision. This framework helps to understand how legal systems cope with the incompleteness of law. In doing so, it sheds a different light on the debate about the characteristics of legal rules by using real option theory.

The paper is structured as follows. Section (2) justifies the interpretation of legal rules as real options. Section (3) evaluates the flexibility of standards. Section (4) shows that

[3]See also Posner (1999), for a analysis of legal rules from an evolutionary perspective.

the sensitivity of legal rules to obsolescence affects the value of waiting in lawmaking.

2 LEGAL RULES AS REAL OPTIONS

How should a producer of law evaluate legal rules? What characteristics should be chosen in an evolving environment? An original way to analyze these choices is to consider legal rules as real options. Dixit and Pindyck (1994) notice that real option theory can be applied to many non-economic issues and particularly to legal reforms[4]. In this section, the real option framework is briefly reviewed and the relevance of its application to the issue of obsolescence in lawmaking is discussed.

2.1 THE DYNAMICS OF THE REAL OPTIONS APPROACH

After the simultaneous success of Merton (1973) and Black and Scholes (1973) in the early seventies, real option theory marked a great progress in the domain of investment decisions in corporate finance. With this theory, the value of a firm or a project is not only the sum of the value of the current assets (Net Present Value, NPV) but also the value of the future opportunities to invest. In particular, this analytical framework is well adapted to the evaluation of a firm's "goodwill", as it allows to take into account more subjective values.

Furthermore, while the classical NPV criterion implicitly assumes that the future value of the investment is known, option theory introduces the cost of uncertainty in the evaluation of projects. Uncertainty is formalized by the assumption that the underlying asset price follows a stochastic process. Indeed, the price of each of these underlying opportunities, such as the price of commodities or the demand level on a particular market, varies stochastically and is consequently impossible to forecast.

In order to apply real options theory, an investment project has to be characterized by the uncertainty on its future cash-flows, the irreversibility of its investments, and flexibility of the project. The latter refers to the ability to take advantage of favorable circumstances and to avoid unfavorable ones. The existence of an option value depends on flexibility. Many forms of flexibility exist and thus many types of real options have to be considered. Flexibility may lie in the possibility to delay the investment. Flexibility can also bear on the *ex post* choice of the type of output.

[4]See Pindyck and Dixit (1994), p. 23-25. They particularly focus on the value of waiting in lawmaking: "*Given some legislative and administrative costs of changing laws, our theory suggests that the option to wait and see if the trend of opinion will reverse itself has some value*".

2.2 VARIOUS OPTIONS FOR LAW MAKERS

As an investor, the lawmaker[5] compares the relative costs and benefits of the different formulations of legal rules. The costs and benefits of rules compared to standards depends on the variability of contingencies and on the degree of innovation in the environment. Indeed, legal rules provide a flow of services, such as informational benefits about the way to behave in human interactions[6]. From a static point of view, the law and economics literature emphasizes the fact that specific rules do better than general rules but that they are more costly to create. Posner (1992) remarks that precise rules reduce information costs of litigants and adjudicators during the trial. When matters are less clear and more difficult to predict, parties' expectations of the outcome of the adjudication are more likely to diverge. As a result, parties to a dispute will tend to settle less often and the litigation rate increases[7]. On the contrary, precise law provide more "guidance" and consequently increases the deterrent or preventive effects of legal rules. To sum up, when we consider the optimal design of rules, the flow of benefits from law comes from the ability to guide behavior and to avoid costs. Thus, the value of law is directly linked with its informational contents. The more precise the information is, the more parties and judges are informed before and during litigation, and the lower is the cost incurred by adjudicators.

Ehrlich and Posner (1974) analyze the relation between precision and efficiency of the legal process, showing that the degree of precision of a legal rule is the main determinant of the reduction of lawsuit costs, as it allows better guidance provided to courts. They recognize the importance of information costs, especially when the legal command potentially covers many different behaviors.

Obviously, this result may no longer be valid when a time dimension is added[8]. More precisely, facing significant changes in a given area, the law may not fit reality any longer. In such a case, the value of legal rules is reduced, since the flow of its services stops. Limits to human capacity and the ambiguity of terms prevent producers of rules from accurately and exhaustively listing all possible contingencies under which a rule is to be

[5] We assume that the lawmaker is a risk neutral benevolent investor. However, we are aware of the interest-group perspective that analyzes the influence of lobbies on the political process. In particular, precise legislation may reflect lobbies' preferences and limit the discretionary power of judges. See for example Stigler (1971), Landes and Posner (1975) and Mahoney and Sanchirico (2005).

[6] It is quite natural in the field of economics of contracts to consider that courts and legal systems contribute to solving moral hazard and adverse selection problems (see for instance Baker, Gibbons and Murphy, 1999 and the literature therein).

[7] See also Cooter et Rubinfeld (1989) on litigation versus settlement in a differing perception model, Johnston (1991, 1995) on bargaining under rules versus standard, and Spier (1994) on the impact of the design of damage awards in litigation versus settlements and on the ex ante level of care in an assymetric information model.

[8] Ehrlich and Posner (1974) remark that "*we have largely ignored the cost and benefits associated with the time dimension of legal regulation*" p. 278.

activated. This kind of incompleteness is recognized as an issue that the creator of law has to deal with: it leads to deterrence problems which may only be taken into account in a dynamic perspective and not in a static one. However, according to their degree of precision, legal rules have different sensitivities to obsolescence. According to Ehrlich and Posner (1974), "*obsolescence is not a serious problem with regulation by standards*" and that "*the more detailed a rule is, the more often it will have to be changed*"[9]. In other words, a limit to obsolescence consists in choosing ambiguous terms. However, ambiguity implies divergent interpretations, and thus contributes to the incompleteness of law. What is important to note is that while both legal gaps and ambiguity define incompleteness of law (Bowers, 2000,Pistor and Xu, 2003), ambiguity is included intentionally in the law. Indeed, ambiguous terms present some benefits that are highlighted in the real options approach described in the next section.

Moreover, the costs of enacting a precise law are higher than the enactment costs generated by a general law. Indeed, legislators have to find an agreement on more points (Posner, 1992). Following Kaplow (1992, 1999), informational costs are incurred *ex ante* by the producer of law in the case of rules while they are incurred *ex post* by the adjudicator in the case of standards.

When considering legal rules as real investments, two types of options have to be considered. First, while a rule may be compared to a bright line test completely cut off from any circumstantial factor, a standard allows the judge to choose the most relevant interpretation among many other. This flexibility, arising from the additional possibility of choosing, not only to apply one particular content but to apply the most valuable content, can be evaluate by using a particular type of option; "an option on the maximum on multiple risky asset". This idea underlying this option is very intuitive. For example, imagine that a field is bought in t_0 and that the investor has to choose in t_1 to build different types of productive units. The one with the highest value will be chosen in t_1, knowing that their respective values evolve stochastically. The option formula, developed by Stulz (1982) for two assets and by Johnson (1987) on several assets evaluate the flexibility arising from this *ex post* choice. This idea is easily transposable to law. Imagine a legal statement using ambiguous terms such as "a driver should not impose an *unreasonable* risk". This term allows many interpretations according to circumstances. The judge may punish a driver on the basis of the speed, on the basis of level of alcohol in the blood or regarding more general care such as using a mobile phone. On the contrary, a rule allow the judge to sanction only on the basis of one of these content, such as a speed limit[10] as its content is

[9] Id. est.

[10] We are aware that this example is very simplified. The aim is to highlight the flexibility to choose

given *ex ante*. Consider a traffic law putting the speed limit at 130km/hour on motoway. The judge applies it if the driver exceeds the speed limit. In terms of option, this refers to a simple call option[11]: the option is exercised at the time of the judgement only if the value of the underlying asset exceeds the cost to exercise it (the adjudication cost) which is equivalent to say that the law is not applied if not relevant.

Second, flexibility on the timing of the enactment is also valuable. The lawmaker has the ability to choose to wait before creating law in order to collect more information. However, the waiting depend on the degree of precision of rules.

3 FLEXIBILITY VERSUS PROVIDING GUIDANCE

We consider a benevolent risk neutral lawmaker who evaluates different formulations of law. The first step of the analysis is to describe the methodology to evaluate the flexibility of legal rules. The objective is to compare the value of a *rule* with the value of a *standard* which allows (at least) two potential interpretations. A numerical example is given. In the second step,the reasoning is the following: the lawmaker trade off between enacting a standard which provides low guidance but a high degree of flexibility and a rigid rule. Therefore, a decision rule is derived.

3.1 VALUATION OF FLEXIBILITY

The fluctuations of a legal content value are assumed to be uncertain. New informations arise as time goes. Information is unpredictable and completely incorporated in the value of the content. This idea is formalized by the assumption that the value S of a content follows a standard Brownian motion[12]. An increase dS during the interval of time dt has for equation:

$$dS = \mu_S dt + \sigma_S dz$$

where μ_S and σ_S are two constant terms. The increment dz follows a Wiener process, that is $dz = \varepsilon\sqrt{dt}$, with $\varepsilon \sim N(0,1)$. The standard deviation σ_S characterizes the volatility of S, i.e. the variability of contingencies. The constant term μ_S is the drift, that is the part of the change dS which is predictable. Figure 1 represents the fluctuation of a legal content which follows a Brownian motion.

among multiple content rather than among a more limited number of interpretation.

[11] "Call" as the adjudicator has to estimate the cost to have the possibility to apply the law.

[12] This type of Brownian motion is generally used to characterized the fluctuations of raw materials prices. Black and Scholes formulas applied below are based on this hypothesis.

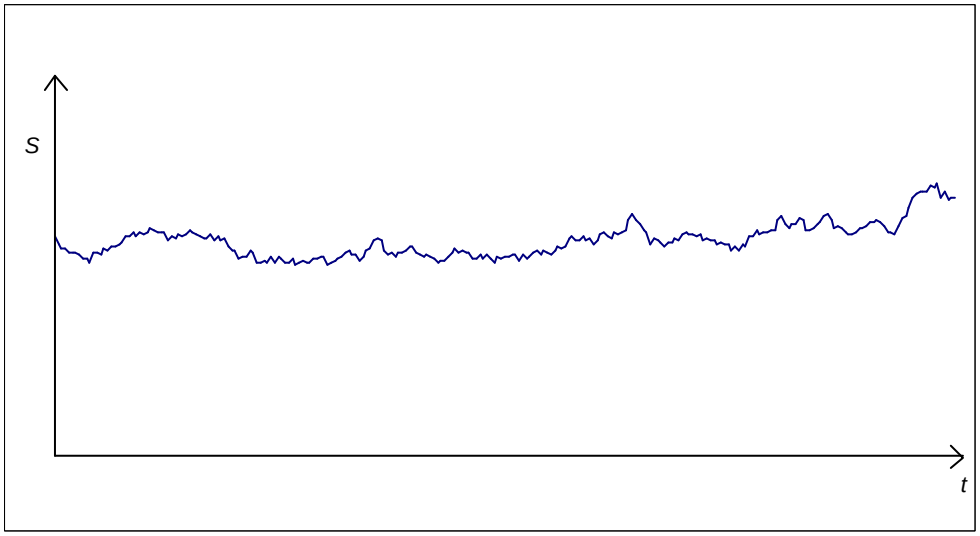

Figure 1: Fluctuations of a legal content value, with $\mu = 0.002$ and $\sigma = 0.02$

The possibility to apply a rule can be evaluated by a simple European call option[13]. The Black and Scholes formula[14] for the European call option is the following:

$$C(S_i, K, T) = S_i N(d_1) - K e^{-rT} N(d_2) \tag{1}$$

with

$$d_1 = \frac{\log[\frac{S_i}{K}] + (r + \frac{{\sigma_i}^2}{2})T}{\sigma_i \sqrt{T}} \tag{2}$$

$$d_2 = d_{1-}\sigma_i \sqrt{T} = \frac{\log[\frac{S_i}{K}] + (r + \frac{{\sigma_i}^2}{2})T}{\sigma_i \sqrt{T}} \tag{3}$$

K is the strike price of the call option[15], that is the cost of the judgement or the cost to apply the sanction and T the time of the judgement, and S_i the initial value of the content i. We assume that μ_S equals r; the risk free rate. The lawmaker is assumed to be risk neutral. Therefore, optimal allocation of lawmaking investments requires that μ equals the risk free r. $N(x)$ is the cumulative function of a variable x which follows a standardized normal distribution $N(0, 1)$.

To illustrate, we assume that at date 0 the content of law equals $S = 40$, as well as the cost to apply the law K. The rule give a judge the right to apply law if at date $T = 10$,

[13] This type of option is called "European" as the time T to strike the option is fixed, while the date to strike "American" options is not specified in advance.

[14] See Black and Scholes (1973) and Merton (1973).

[15] For simplicity, we assume here that the cost of the judgement is the same with a standard and with a rule. However, the cost incurred by the judge in interpreting a fuzzy standard rather than applying a simple rule might be more important.

the content value S_i is higher than K. The volatility of the content value is equal to 0.3, and the risk free rate equals 0.1. The parameters values reflect the quite reasonable idea that the benefits of the rule are significantly positives and that the interest rate is small. These hypothesis are generally accepted for real investment[16]. The value of the rule, that is the value to apply the content amounts to[17]:

$$C(40, 40, 10) = 26.89$$

The value of the option to enforce law on the content S_i is around 26.89. To have a meaning, this value has to be compared with the one obtained for a standard (that is, an option on the maximum of two risky assets) with the same numerical values.

To simplify calculations, we assume that there are only two possible interpretations of a standard (i.e. two contents A and B)[18]. Under a standard, a judge choose the maximum between S_A, S_B and 0, while under a rule his choice is limited to the value of a single content S_i (with $i = A, B$) at the date of the judgement and 0. Assume that the *ex ante* value S of two contents is the same: $S_A = S_B$. The value of the call on the maximum of S_A and S_B can be calculated with the following formula, given by Stulz (1982)[19]:

$$MX(S_A, S_B, K, t) = C(S_A, K, t) + C(S_B, K, t) - M(S_A, S_B, K, t)$$

with $C(S_A, K, t)$ and $C(S_B, K, t)$ the ordinary call on S_A or S_B. To calculate MX, we have to give numerical value to the degree of correlation between the two contents ρ_{S_A,S_B}. Positive correlation is justified by the fact that two interpretations of a single standard are generally linked. For example, regarding the legal statement on the unreasonable risk, at least two contents "do not drink alcohol" and "do not exceed 90 kilometers per hour" can be found. These two contents are linked, as alcohol is often associated with high speed. In this example, the degree of correlation is high. The degree of correlation is set at 0.5.

Call options on the maximum of two risky assets have to be evaluated in two steps. First, the value of a European option on the minimum of two assets $M(S_A, S_B, K, t)$ is

[16] For example, see numerical application by Hull (2004) and Goffin (1995,2004).

[17] By substitution, we find (2) and (3):

$$\begin{aligned} d_1 &= 1.528434202 \\ d_2 &= 0.5797509039 \end{aligned}$$

We can use a polynomial approximation to calculate $N(d)$ and get: $N(d_1) = 0.9367975968$ and $N(d_2) = 0.7189587401$.

[18] For simplicity reason, we calculate the option for two possible assets. The results are transposable to multiple assets options, as the increase of the number of asset increase the value of the option.

[19] The explanation of Stulz method has been clearly exposed in Goffin (1995).

calculated. Then, the value on the maximum $MX(S_A, S_B, K, t)$ is deduced. We find that:

$$M(S_A, S_B, K, t) = 12.87186829$$

See Appendix 6.1 ■

As the initial values of both contents are equal, we get $C(S_A, K, t) = C(S_B, K, t)$ and the estimate value of the call on the maximum of S_A and S_B approximately amounts to:

$$MX(S_A, S_B, K, t) = 40.91$$

By comparing the estimations of the ordinary option C_i and of the option on the maximum MX calculated with the same numerical values, we observe that the value of law increases with the number of possible *ex post* contents: a standard has a higher value than a single rule, everything else remaining equals[20]. The difference between MX and C represents the value of flexibility induced by the choice between two contents and not only one.

The scope of a standard consists in the number n of contents $S_{i=1,..,n}$ and in the strength of their links, that is the degree of correlation. The lower the correlation between contents, the larger the scope of a standard. For a correlation ρ_{S_1,S_2} reduced to 0.25, the option on the maximum of S_1 and S_2 approximately amounts to:

$$MX(S_1, S_2, K, t) = 44.49$$

This result highlights the relevance of the scope of a standard. The larger the scope, the higher the standard value.

This first step in the analysis of the formulation of legal rule in the real options framework emphasizes the value of flexibility of standard in comparison to rules' rigidity in an uncertain environment. The value of flexibility of standards should be taken into account by lawmakers when dealing with cost benefit analysis, particularly in changing and complex areas of law. Such result does not question the benefits in terms of guidance of precise enactment, but highlights the "adaptability" of general rules. Indeed, standards allow judges to adapt legal rules to fit the circumstances by creating precedents but also to avoid the issue of obsolescence of law. If technological changes arise and that the value of a specific content is strongly reduced, the judge still have in hands other potential

[20] Obsviously, a lawmaker should compare the value of many rules with a standard. However, a lawmaker may not be able to foresee every contingencies (and be aware that there exist unforeseeen contigencies) or it may be too costly to write a rule for each one. In this case, the comparison of a single rule with a standard is relevant.

contents[21]. On the contrary, a rigid rule would probably have no value in similar circumstances. In these second step, we formalize the trade-off between rules and standards by taking into account a major benefit of rules: "guidance".

3.2 THE TRADE-OFF BETWEEN PROVIDING GUIDANCE AND FLEXIBILITY

The choice between rules and standards is a familiar one to lawyers. In some cases, legal norms dictate particular outcomes; in others, they set forth more open-ended tests, whose application is left to the discretion of judges. As noted before, speed limit may take the form of a rule requiring drivers to go no more than 130 kilometers per hour, or a standard requiring them to travel at a safe speed. On one side, we want laws to be clear so that agents exactly know what behavior is expected (*guidance*). This argues in favor of a rule. For instance, in the case of copyright, we want to know who owns what, for how long, how far the copyright owner's rights reach, which unauthorized uses are excused or authorized. On the other side, we want our laws to be fair, what pleads in favor of a standard. The reason is that fairness frequently means being flexible. In a way, flexibility is an enemy of clarity since we do not know in advance if a court will hold that the general standard of the law will bend to the particular facts at hand.

Our argument is that options theory could help to solve this trade-off. In the model, we assume that more flexibility is provided at the cost of less informational value. The difference between MX and C captures the value of flexibility. Let γ captures the lower *ex ante* informational benefits brought by standards compared to those brought by rules, as discussed in section (2). γ varies between 0 and 1, such that $\gamma \in (0;1)$[22]. When γ is closed to zero, the *ex ante* informational benefits of a standard are very low. On the contrary, γ close to the unity characterized a legal statement which brings many information how to behave, and thus very much certainty.

To make easier the comparison, we assume that the initial value of both statements are the same: $S_1 = S_2$. Therefore, we obtain $C(S_1, K, t) = C(S_2, K, t) = C(S_i, K, t)$. Thereby, a legislator should create a standard rather than a rule if $\gamma MX(S_1, S_2, K, t) > C(S_i, K, t)$, with $i = 1, 2$.

[21] Although light carts have disappeared, a statement requiring a driver to adopt "a *reasonable* speed" is still adapted for motor vehicle, while a statement setting a particular speed would have become obsolete. This issue of obsolescence is further developed in section (4).

[22] The value of the informational benefits brought by the agent is never as high as the value of the informational benefits brought by a rule.

The following decision rule is derived:

Remark 2.1: *There exists a unique threshold value* $\bar{\gamma} \in [\frac{1}{2}, 1)$*, above which the lawmaker should create a standard rather than a rule, everything else remaining equal. The threshold value* $\bar{\gamma}$ *equals* $\frac{C(S_i,K,t)}{MX(S_1,S_2,K,t)}$.

See Appendix 6.2 ■

This proposition has a very straightforward intuition. In order to choose between a standard or a rule, the lawmaker has to compare the flexibility and the guidance values. The lower $\frac{C(S_i,K,t)}{MX(S_1,S_2,K,t)}$, the higher the value of flexibility. If the informational benefits of a standard are too low ($\gamma < \frac{1}{2}$), a rule is always preferred. For instance, this might be the case for patent or copyright laws because the benefits of the general standard of fairness are small in a context of fast innovation where firms need before all precise informations about the extent of the protection. The society valuation of guidance (γ) depends on the agents' degree of aversion. The higher the degree, the higher the valuation of law guidance. If $\frac{1}{2} < \gamma$, the lawmaker has to balance the relative advantage of both type of legal statements. If $\gamma < \frac{C(S_i,K,t)}{MX(S_1,S_2,K,t)}$, a rule is preferred to a standard. On the contrary, if $\gamma > \frac{C(S_i,K,t)}{MX(S_1,S_2,K,t)}$, the value to flexibility of a standard is sufficiently high to tip the balance in favor of the standard.

Until now, we assert that precise rules have a higher informational value than standards. However, precise rules are also more sensitive than standards to innovation. This is due to their lack of flexibility. Therefore, a benevolent lawmaker has to take into account the risk of obsolescence in the evaluation of the rule. In a highly innovating context, the producer of law may decide to wait before investing in law in order to obtain more information or to invest in a large scope standard. The effect of such characteristics on the choice to invest in law or wait in order to get more information is developed in the following section.

4 ENACTMENT TIMING AND LEGAL RULE SPECIFICITY

In the preceding analysis, legal rules are considered as European options: the time to exercise the option is fixed in advance. However, the lawmaker may decide to wait before creating the law in order to get more information about the area. In this case, the option is called "American": The time t of exercising "American" options is not fixed ($t \leq T$). Applying a model of investment under uncertainty in continuous time[23], it is possible to

[23] This type of model was first developed by McDonald and Siegel (1986)

show that there is a value of waiting in lawmaking (Parisi and al., 2004).

In the analysis below, another source of uncertainty is analyzed: uncertainty regarding innovation. Consequently, law may become obsolete[24]. In a general setting, Jones and Ostroy (1984) formalizes the notion of flexibility and shows that the value of flexibility depends on the amount of information the decision maker expects to acquire. They discuss the notion of beliefs and propose the following behavioral principle: "*the more variable are the decision makers' beliefs, the more flexible is the position he will choose*" and notices that *"current doubts may be partially resolved in the near future. This prospect decrease the attractiveness of the long-term commitment, in that one is able to respond less fully to new information".* In the legal framework, two solutions are in the hands of a lawmaker in order to choose a "*flexible position*": to wait to enact the law until he obtains "enough" information (that is, the value of the legal content is high enough) or to adopt a more general rule.

4.1 FLUCTUATION OF A LEGAL CONTENT VALUE WITH OBSOLESCENCE

The representation of the evolution of benefits with a Brownian motion necessarily implies that the legal rule exists and yields benefits for ever, as represented by the continuous curve on figure 2. Consequently, the formalization of the evolution of the benefits S as a Brownian motion is not suitable with the possibility of obsolescence. To capture the idea that obsolescence may happen only once, at a single time non determinable previously, it is more accurate to use a Poisson process (Dixit and Pindyck, 1994). Thus, we assume that S follows a mixed Brownian motion jump process such as:

$$dS = \alpha S dt + \sigma S dz - \phi S dN \tag{4}$$

where dN is the increment of a Poisson process. There is a probability λ that an event occurs in the interval dt.

$$\begin{aligned} \Pr(dN &= 1) = \lambda dt \\ \Pr(dN &= 0) = 1 - \lambda dt \end{aligned}$$

If an event occurs, the value S of the legal content drop by a fixed percentage ϕ during the period dt,with $0 \leq \phi \leq 1$. If $dN(t) = \phi S dt$, the value of the benefits decreases from ϕ

[24]In the model, innovation is assumed to be exogeneous and not an output of an active research by agents looking for news technologies that enable them to avoid the law (Malik, 1990).

times its initial value. We find:

$$dS = (\alpha - \phi)Sdt + \sigma Sdz$$

If $\phi = 1$, the legal rule creates some benefits and loses them immediately, and then creates no more benefits:

$$dS = \alpha Sdt + \sigma Sdz - Sdt \tag{5}$$

The mixed Brownian jump process described by (5) is represented by the discontinuous curve in figure 1. It describes the case where a loophole is found in law and every potential offender circumvents the law. The mixed Brownian motion jump process is partially predictable as the expected rate of change $E(dN)$ is different from zero, with $E(dN) = \phi\lambda dt$ and $V(dN) = \phi\lambda dt$. The expected change of S is not α but instead $E(dS) = (\alpha - \phi\lambda)$, as on each interval dt, there is a probability λdt that V will fall by 100ϕ percent[25].

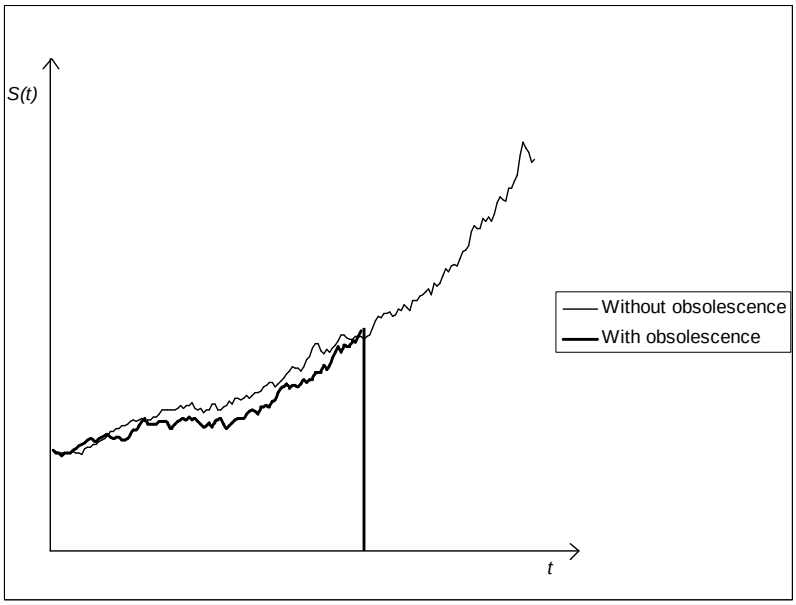

Figure 2: Legal content value fluctuations with and without obsolescence, $\mu = 0.01$, $\sigma = 0.02$, $\lambda = 0.1$

As $N(t)$ follows a Poisson distribution, the probability of an event to happen during one interval of time dt is independent from the probability of an event happening in any another interval. Furthermore, dz and dN are independent, that is $E(dzdN) = 0$.

[25] Of course, one can imagine intermediate situation where the obsolescence is not so radical but, our aim is to consider the kind of tradeoffs that the rulemakers have to solve.

4.2 ENACTMENT TIMING

A risk-neutral producer of law decides at each interval dt whether she wants to exercise the option, that is to promulgate the rule, or to continue the waiting. The decision to invest in law can be made at any time and can be indefinitely postponed. The lawmaker chooses the maximum between the net benefits $S(t) - I$ and the present expected value of the option $1/(1+r)E[F(S, t+dt)]$, that is between the left part and the right part of the Bellman equation (6).

$$F(S) = max\{S(t) - I; 1/(1+r)E[F(S, t+dt)]\} \tag{6}$$

where I is the sunk cost to implement the rule[26] and r the risk free interest rate[27].

The producer of law can invest in two ways: a specific rule or a general rule. When decided, the enactment is immediate for both types of rules. We know from section (3) that sensitivity to obsolescence is higher for precise rules than for general rules, that is:

$$\lambda_S \leq \lambda_R$$

Further, informational benefits $\alpha + \delta$ are higher for precise rules rather than for general rules, which should compensate the expected loss due sensitivity to obsolescence λ. In terms of portfolio choices, the risk free rate r remain constant, as explained by Merton (1976). Indeed, no law maker would choose a precise law if the negative risk effect is not counterbalanced by higher benefits: $r - \delta = \alpha - \lambda$. In other words, the increase in $\alpha + \delta$ neutralizes the effect on the negative expected change of S from a higher λ.

By dynamic programming (Pindyck and Dixit, 1994), we obtain (for $\phi = 1$):

$$F(S) = AS^{\beta_1}$$

with

$$\beta_1 = \frac{1}{2} - \frac{(r + \lambda - \delta)}{\sigma^2} + \sqrt{(\frac{r + \lambda - \delta}{\sigma^2} - \frac{1}{2})^2 + 2\frac{(r+\lambda)}{\sigma^2}}$$

and with A a constant term equals to:

$$A = \frac{S^* - I}{(S^*)^{\beta_1}} = \frac{(\beta_1 - 1)^{\beta_1 - 1}}{(\beta_1)^{\beta_1} I^{\beta_1}}$$

[26] We assume that I is equal for a particular law at all times. This hypothesis is realistic if we consider that the decision to invest in law should not last too long so as to modify both institutional and informational costs.

[27] Now we have: $r = \alpha + \delta$, with δ the short term benefits. δ have to be included as it is the short term benefit of the rule, that is what benefit the rule would brought if it was enacted at time t.

The optimal value S^* is defined by:

$$S^* = \frac{\beta_1}{\beta_1 - 1} I$$

See Appendix 6.3 ■

We observe that $S^* > I$, as $\beta_1 > 0$. The simple use of the NPV criteria is not sufficient: the threshold above which the legal content value is high enough to enact the rule is higher than the cost to promulgate it.

Table 2 shows β_1, S^* and A function of λ. The net effect of λ over the critical value S^* is positive[28].

λ	β_1	S^*	A
0	2.000	2.000	0.250
0.01	1.850	2.175	0.279
0.02	1.732	2.366	0.307
0.1	1.317	4.158	0.487
0.3	1.124	9.062	0.677
0.5	1.077	14.038	0.758
0.7	1.055	19.027	0.805
1	1.039	26.519	0.846

Table 1 Values of β_1, S^* and A when λ varies and $r = \delta = 0,04$, $\phi = 1$, $I = 1$ and $\sigma = 0,2$.

Figure 3 plots the waiting option value $F(S)$ as a function of the legal content value S. Numerical values are the following: $r = \delta = 0.04$, $\phi = 1$, $I = 1$, $\sigma = 0.2$. For a probability of obsolescence given as $\lambda = 0.01$ for the standard, the coefficient β_1 amounts to 1.850 and the constant term A to 0.279. Equivalently, for $\lambda = 0.1$ in the case of the rule, coefficients respectively are 1.317 and 0.487. Thus, the curves of the functions $F(S) = AS^{\beta_1}$ can be draw for a general rule and for a precise one. The upper curve refers to the precise rule option value. Promulgation costs I are assumed to be equals for a rule and a standard. Consequently, a unique $S - I$ straight line is plot and tangency points with $F(S)|_S$ and $F(S)|_R$ gives threshold values S_S^* and S_R^*.

[28] The opportunity cost of investing immediately rather than waiting increases with the risk of obsolescence if the effect on the expected gain is neutralized by the increase in the rate of growth of benefits so as to keep constant the interest rate r.

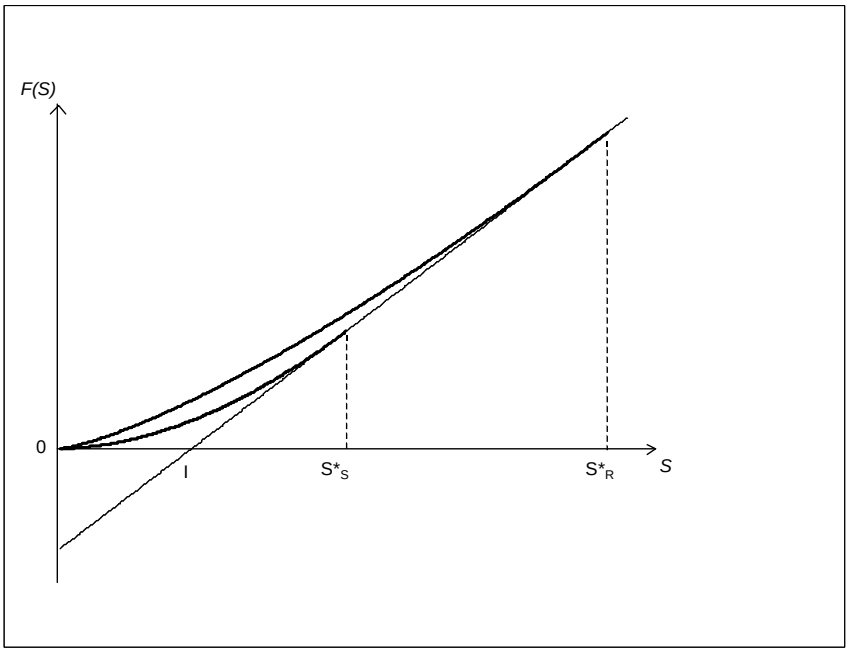

Figure 3: Threshold values for a standard S_S^* ($\lambda = 0.01$) and a rule S_R^* ($\lambda = 0.1$), with $r = \delta = 0.04$, $K = 1$, $\sigma = 0.2$

Each curve is not valid after the relevant threshold. On $]0, S_S^*[$ it is optimal to wait before investing as $F(S)_S > S - I$. At S_S^*, the producer of law is indifferent between waiting and enacting a standard immediately. On $]S_S^*, \infty[$, it is optimal to enact a standard immediately. The same reasoning applies for S_R^*. We also observe that the value of the option to wait is always higher for precise rule than general ones. The legal content value threshold is higher for precise rules, meaning that the lawmaker should wait to have higher benefits to invest in precise rules.

The producer of law faces a trade-off between the high guidance benefits of a precise rule and the low sensitivity to the environment of general ones. She solves this trade-off following the rule describe by S^*, which is function of the innovation in the environment, and the benefits that a higher degree of precision would bring in each case. λ may be considered as an index of the adaptation of the rule to environment. When the sector is not innovating, the difference in the risk of obsolescence for general rules and precise rules is very small. In such a case, the choice between precise and general rule falls on the latter. Indeed, λ drops while the benefits α remains high. On the contrary, when the sector is innovating, the difference rises.

Until now, we assumed that the cost of investment in law I is constant for all types of rule. In practice however, the cost of promulgation of a precise legal rule is generally

higher than that of a general rule, such as :

$$I_S \leq I_R$$

We can easily determine the effects of differences in costs using the same parametrization as before (with the same obsolescence probability):

I	λ	β_1	S^*	A
1	0.7	6.603	1.178	0.060
1.1	0.7	6.603	1.296	0.035

Table 2 $r = \delta = 0,04$, $\phi = 1$, and $\sigma = 0,2$.

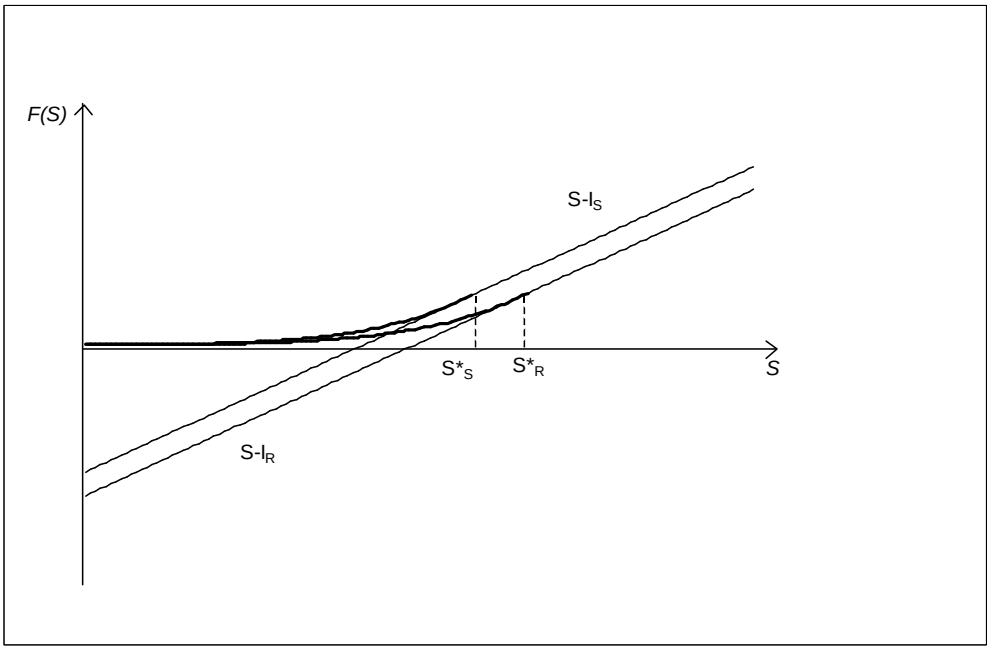

Figure 4: Threshold values for a standard S_S^* ($I = 1$) and a rule S_R^* ($I = 1.1$), with $r = \delta = 0.04$, $K = 1$, $\sigma = 0.2$

Figure 4 shows that S^*[29] is negatively affected by the cost of investment. Net benefits are also affected; $S - I_R < S - I_S$. Consequently, S^* is higher if promulgation costs are higher.

[29] Recall that

$$P^* = \frac{\beta_1}{\beta_1 - 1}.I$$

So that

$$\frac{\partial P(I)}{\partial I} = \frac{\beta_1}{\beta_1 - 1} > 0$$

To sum up, the content threshold value for a precise rule is higher due to (1) a higher risk of obsolescence and (2) higher promulgation costs. This underlined the fact that a standard more rapidly be enacted, before precision that may come later. On the opposite, a non ambiguous result can not be given for the comparison of the waiting option values: it depends on the relative importance magnitude of promulgation costs and obsolescence risk. The higher the obsolescence risk, the higher the value to wait. The higher the cost, the lower the value.

5 CONCLUSION

The paper attempts to develop a theory to understand how a legal system copes with incompleteness of law, and to deal with the trade-off between potential gaps in law and ambiguous terms in law. The theory applies real options theory to look at characteristics of legal rules. It proposes an evaluation of the *legal flexibility* in a real options perspective. And it analyzes the interaction between flexibility and the value of waiting in lawmaking. This is particularly important to evaluate legal policies like that based on the *precautionary principle*. Our approach shows that the optimal decision when information on future risks is incomplete is not necessary to wait for an improvement of knowledge. There is a trade-off between flexibility and the timing of the decision.

The approach is also interesting because real option theory allows us to get a better picture of how legal rules deal with the issue of obsolescence. This framework seems particularly well adapted to this question as it allows to formally represent the uncertainty of the environment and thus of the evolution of the value of services yield by a legal rule.

Two types of uncertainty have to be distinguished in legal systems: current uncertainty about the value of the legal services and uncertainty on obsolescence. Two main solutions are in the hands of the lawmaker to deal with the latter. The first one is simply to wait, in order to get more information on the sector[30]. The second one is to lower the degree of precision of law. We describe the interaction between solutions.

Our analysis proceeds in two steps. First, we evaluate rules and standards and derive a decision rule between both formulation. Second we show that the value of waiting increases with the degree of precision of law.

The first step consists in comparing legal standards to options on the maximum of multiple contents. These options are exercised at the time of judgement. Judges choose the content of the law with the maximum value: they make fact specific adjudication. Rules does not give the judge such a margin of decision. The content is given *ex ante*.

[30] See for example the internet sector.

It often results in a less than perfect fit to reality. When there is uncertainty and when the standard at least gets two potential contents *ex post* , we find that its value is higher than the value of the rule. This result provides an estimation of the value of flexibility. However, rules provide guidance to agent. Therefore, a lawmaker has to trade-off between the providing guidance and flexibility.

As discussed in the first step, rules are much more sensitive to innovation as they are fully specified *ex ante*, that is before the judgement. Thus, their high degree of specificity implies a high risk of obsolescence. This characteristic has to be taken into account in the choice of the timing to enact law. We show that the degree of precision positively affects the value of the waiting.

The analysis above only draws a very rough picture of the diverse problems they may face in dealing with the writing of rules. More than the usual net present value criteria, the real options framework allows to accurately estimate the decisions of creation of law. The more variable behaviors or events are, the more valuable this flexibility is. This framework also helps to understand how a legal system copes with incompleteness of law.

However, the paper does not distinguish between primary and secondary lawmaking: legislation versus regulation. Generally, legislation is general and flexible and the implementing regulations are specific. Moreover, usually the lawmaking strategy combines both legislation and regulation. So, it would be interesting to study the optimal division-of-labor between legislators and regulators.

6 APPENDIX

6.1 ESTIMATION OF A CALL OPTION ON THE MAXIMUM OF TWO RISKY CONTENTS

The value of a European option on the minimum of two assets $M(S_1, S_2, F, t)$ is defined as

$$M(S_1, S_2, K, t) = S_1 N_2(\underline{d}_1) + S_2 N_2(\underline{d}_2) - K \exp(-rt) N_2(\underline{d}_3) \tag{7}$$

with,

$$\begin{aligned} d_1 &= [\gamma_1 + \sigma_{S_2}\sqrt{t}; \frac{\log(\frac{S_1}{S_2}) - \frac{1}{2}\sigma^2 t}{\sigma\sqrt{t}}; \frac{\rho_{S_1,S_2 *}\sigma_{S_2} - \sigma_{S_2}}{\sigma}] \\ d_2 &= [\gamma_2 + \sigma_{S_1}\sqrt{t}; \frac{\log(\frac{S_2}{S_1}) - \frac{1}{2}\sigma^2 t}{\sigma\sqrt{t}}; \frac{\rho_{S_1 S_2}\sigma_{S_2} - \sigma_{S_1}}{\sigma}] \\ d_3 &= [\gamma_1; \gamma_2; \rho_{S_1,S_2}] \end{aligned}$$

and ,

$$\sigma^2 = \sigma_{S_1}^2 + \sigma_{S_2}^2 - 2\rho_{S_1,S_2} * \sigma_{S_1} * \sigma_{S_2}$$

$$\begin{aligned} \gamma_1 &= \frac{\log(\frac{S_2}{S_1}) + (r - \frac{1}{2}\sigma_{S_2}^2)t}{\sigma_{S_2}\sqrt{t}} \\ \gamma_2 &= \frac{\log(\frac{S_1}{S_2}) + (r - \frac{1}{2}\sigma_{S_1}^2)t}{\sigma_{S_1}\sqrt{t}} \end{aligned}$$

Assume that a couple of variables (a, b) follows a standardized bivariate normal distribution. $N_2(\underline{d}) = M(a, b, \rho)$ is the cumulative probability of this standardized bivariate normal distribution, with ρ the coefficient of correlation between the two variables: it is the probability that the first variable is less than a and the second variable is less than b.

After having substituted σ_{S_1} and σ_{S_2} by their numerical values in (**??**), we get:

$$\sigma^2 = 0.09$$

Therefore, γ_1 and γ_2 can be easily calculated by substituting r and T in (**??**) and (**??**) (in our case, $\gamma_1 = \gamma_2$):

$$\begin{aligned} \gamma_1 &= 0.1833333333 * \sqrt{10} \\ &= \gamma_2 \end{aligned}$$

Thus we get the threshold values d_1, d_2 and d_3:

$$\begin{aligned} d_1 &= [0.4833333333 * \sqrt{10}; -0.474341649; -0.5] \\ d_2 &= [0.4833333333 * \sqrt{10}; -0.474341649; -0.5] \\ d_3 &= [0.579790904; 0.579790904; 0.5] \end{aligned}$$

Thus, the algorithm of Drezner (Drezner, 1978, Hull, 2000) is applied to estimate the value of the cumulative probability in a standardized distribution for $d1$, $d2$ and $d3$.

We found that:

$$N_2(d_3) = 0.6060868980$$

$$N_2(d_1) = 0.2723818083$$

$$N_2(d_2) = 0.2723818083$$

By substituting S_1, S_2, K, r, T by their numerical values and $N_2(\underline{d}_1)$, $N_2(\underline{d}_2)$ and $N_2(\underline{d}_3)$ by their approximation in Stulz formula(7), we get:

$$M(S_1, S_2, K, t) = 12.87186829$$

6.2 PROOF OF THE REMARK 2.1

Initial values of S_1 and S_2 are equal. Consequently, we obtain:

$$C(S_1, F, t) = C(S_2, F, t) = C(S_i, F, t), \text{ with } i = 1, 2$$

Thus, the expression $\gamma MX(S_1, S_2, F, t) - C(S_i, F, t)$ can be rewritten as (by assumption, $\gamma > 0$):

$$\frac{(2\gamma - 1)}{\gamma} C(S_i, F, t) - M(S_1, S_2 F, t)$$

If $\gamma < \frac{1}{2}$, then $\frac{(2\gamma-1)}{\gamma} C(S_i, F, t) - M(S_1, S_2 F, t) < 0$. If $\gamma = 1$, then $\frac{(2\gamma-1)}{\gamma} C(S_i, F, t) - M(S_1, S_2, F, t) > 0$. As options values C and M are not function of λ, the function $f(\lambda) = \frac{(2\gamma-1)}{\gamma} C(S_i, F, t) - M(S_1, S_2, F, t)$ is continuous and strictly increasing in γ on the interval $]0, 1[$ as:

$$\frac{\partial f(\lambda)}{\partial \gamma} = \frac{1}{\gamma^2} C(S_i, F, t) > 0 \ \forall \gamma \in]0, 1[$$

Due to a simple intermediate value argument, there exists a unique threshold value $\bar{\gamma}$ such that: a rule is preferred if γ is lower than $\bar{\gamma}$. Otherwise, a standard is preferred.

Therefore, the unique threshold value $\bar{\gamma}$ such that $\bar{\gamma} MX(S_1, S_2, F, t)$ equals $C(S_i, F, t)$

is defined by:

$$\bar{\gamma} = \frac{C(S_i, F, t)}{MX(S_1, S_2, F, t)}$$

6.3 VALUATION OF WAITING TO ENACT

In the continuation region, the Bellman equation can be re-written as:

$$rF(P,t) = E[dF] \tag{8}$$

That is, over a time interval dt, the total expected return on the creation of law opportunity $rF(P)$ is equal to the expected benefits growth rate. Suppose that P follows the process of equation (4), and consider a function $F(P,t)$ that is at least twice differentiable in P. We expand dF using Ito's Lemma:

$$\begin{aligned} dF &= \{\alpha P F_P + \frac{\sigma^2}{2} P^2 F_{PP} + [F((1-\phi)P) - F(P)]\lambda\}dt + \sigma P F_P dz \\ &\quad + [F((1-\phi)P) - F(P)](dN - \lambda dt) \end{aligned}$$

With $E(dz) = 0$ and $E(dN) = \lambda dt$, we get:

$$E(dF) = (\alpha - \lambda\phi)PF_P dt + \frac{\sigma^2}{2} P^2 F_{PP} dt + F((1-\phi)P)\lambda dt - F(P)\lambda dt$$

$$(\alpha - \lambda\phi)PF_P dt + \frac{\sigma^2}{2} P^2 F_{PP} dt + F((1-\phi)P)\lambda dt - F(P)\lambda dt - rF dt = 0$$

Hence, equation (6) can be rewritten as:

$$\frac{\sigma^2}{2} P^2 F_{PP} + \alpha P F_P + \lambda F((1-\phi)P) - (r+\lambda)F = 0 \tag{9}$$

$r = \delta + \alpha - \lambda$, $0 \leq \alpha \prec r$ and $\delta > 0$.The solution must also follows three boundary conditions.

$$F(0) = 0 \tag{10}$$

$$F(P^*) = P^* - I \tag{11}$$

$$F\prime(P^*) = 1 \tag{12}$$

The first condition (10)is that if $P = 0$, then from the mixed Brownian jump process (4), we know that P will never be positive. Consequently, the value to wait is nil and the value of invest immediately negative. (10) refers to the case where there is no policy pur-

pose. At the value matching condition (11) P^*, lawmakers are indifferent between waiting and enacting the law. The "smooth pasting" condition (12) comes from the continuity property of the benefits evolution. This condition is implied by (12). The option value has to be continuous, such that the legislator can create law at any moment, and particularly at P^*. Thus, the curve of the option value $F(P)$ has to be tangent to $P - I$ at P^*.The solution is of the form:

$$F(P) = A.P^{\beta_1}$$

with $\beta_1$the positive solution of (with $r - \delta = \alpha - \lambda$):

$$\frac{1}{2}\sigma^2\beta(\beta-1) + (r+\lambda-\delta)\beta - (r+\lambda) + \lambda(1-\phi)^{\beta} = 0 \text{ with } \lambda > 0 \tag{13}$$

If $\phi = 1$, the positive solution of (13) is:

$$\beta_1 = \frac{1}{2} - \frac{(r+\lambda-\delta)}{\sigma^2} + \sqrt{(\frac{r+\lambda-\delta}{\sigma^2} - \frac{1}{2})^2 + 2\frac{(r+\lambda)}{\sigma^2}}$$

Thus,

$$S^* = \frac{\beta_1}{\beta_1 - 1}K$$

and,

$$A = \frac{S^* - K}{(S^*)^{\beta_1}} = \frac{(\beta_1 - 1)^{\beta_1 - 1}}{(\beta_1)^{\beta_1}K^{\beta_1}}$$

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