The Effect of Patent Continuation on the Patenting Process

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Abstract

Even after final rejection, patent applications are never completely rejected. In the U.S., a patent applicant can reapply after a final rejection by submitting amended applications called continuations. While patent applicants benefit from this procedure (a final rejection is never final), examiners are worse off when examining continuations than when examining new applications. We theoretically investigate the impact of continuation on the patenting process. We find that the continuation process introduces a trade-off for examiners: a reduction in the initial applications' examination intensity can compensate for the loss incurred due to continuation in the case of rejection. Thus, examiners reduce their examination efforts when uncertainty about the innovation's patentability is the highest. When it is more likely that innovations are patentable, examiners tend to grant patents after little scrutiny, which reduces the chance of encountering continuations later on. Abolishing continuing applications could restore examiners' incentives to perform thorough evaluations of patent applications.

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1 Introduction

Over the past 40 years, patent applications and grants have more than quadrupled.[1] This surge in patent applications and grants has been accompanied by many criticisms concerning the quality of granted patents, criticisms that were acknowledged by the U.S. Patent and Trademark Office (USPTO).[2] Following these concerns, contributions to the patent literature have investigated the functioning of the patent system and the process by which patents are granted (Atal and Bar, 2010, 2014; Hall and Harhoff, 2012; Eckert and Langinier, 2014; Langinier and Marcoul, 2016, 2019, 2020; Frakes and Wasserman, 2017, 2020). The rationale for some USPTO rules has also been questioned, such as the continuation rule of patent applications (Quillen and Webster, 2006; Cotropia and Quillen, 2018, 2019).[3] With this rule, the USPTO recognizes that examiners sometimes make mistakes and refuse patents for patentable innovations. By allowing applicants to file for continuation, particularly for a Request for Continued Examination (RCE), which allows applicants to continue once a final rejection has been issued, the USPTO provides them a chance to convince the examiner that their innovation is patentable. Thus, when a patent application is rejected, the applicant can decide to continue submitting the amended applications. In the U.S., refiled continuing applications accounted for 45% of all filed patent applications in 2018 (Cotropia and Quillen, 2019).[4] Furthermore, more than half of the U.S. patent applications filed in January 2001, which received a final rejection, ultimately resulted in

[1] Aggregate data can be found on the WIPO website. In 2022, the USPTO received 457,510 patent applications and granted 361,435 patents, whereas it received 109,625 patent applications and granted 57,888 patents in 1982.

[2] In 2009, the U.S. Chamber of Commerce stated: "The USPTO is an agency in crisis facing significant challenges." More than a decade later, in April 2022, the Editorial Board of the New York Times wrote an article titled "Save America's Patent System."

[3] There are several types of continuation: a 'continuation application' allows applicants to pursue additional claims to an invention disclosed in an earlier application; a 'Request for Continued Examination' (RCE) allows applicants to continue once a final rejection has been issued on an application; a 'continuation-in-part' allows applicants to introduce new subject matter to an existing application; and a 'divisional application' allows applicants to separate claimed inventions when two or more distinct inventions are claimed in the same application (Carley et al., 2015).

[4] Among these continuations, RCE accounted for 28% of all filed patent applications. In 2004, continuations accounted for more than one-third of all files patent applications (Hall, 2006). Between 1993 and 2010, 70% of patents with continuations had one continuation and 15% had three or more continuations, with a maximum of 468 continuations in one application (Dechezleprêtre et al., 2017).

patents in 2006 (Lemley and Sampat, 2010).

A brief description of the U.S. continuation process is as follows. After a final rejection, if the applicant files for an RCE, the request returns to the examiner who has examined the initial application, and the latter is abandoned. This allows the applicant to potentially obtain a patent, even though a final rejection was issued on the initial application. Furthermore, the applicant can keep the initial filing date and have the examination process restarted again. However, for examiners, RCEs are not always welcome. Indeed, examiners have quotas to reach, and their production performance is measured with a count system: for each initial patent application and its disposal (granted or abandoned), an examiner obtains a total count of two. The sum of all counts allows the examiner to achieve his quotas. Even though an examiner receives a total count of two for disposing of a patent application that might be followed by RCE, he obtains a count of less than two from the reevaluation of the application (Marco et al., 2017). In other words, an examiner would be better off with a brand-new application, as he could obtain a total count of two once he disposed of the application.

Because amending an application seems to be a common practice, our objective is to evaluate the effect of patent continuation (after a final rejection) on the patenting process. Thus, we wonder how the re-examination of patent applications affects the examiner's evaluation process and how it affects applicants' decisions to apply for patents and continuations.

To analyze the effect of the continuation rule on patent applicants and examiners' behavior, we propose a theoretical framework that investigates the impact of continuation on the patenting evaluation process. We consider a model in which, at the outset, a patent applicant has an innovation whose patentability is unknown and must decide whether to apply for a patent. If she decides to apply, her innovation is evaluated by an examiner who chooses his effort level to process the application. His effort generates a signal about patentability: it is either good or bad. The examiner then decides whether to follow the signal and grant a patent or not. In the latter case, the applicant can decide to apply for continuation. Both the applicant and examiner benefit from a patented innovation as well as a rejected innovation. Indeed, not only does the examiner receive a salary from processing applications, but he can also obtain a non-monetary benefit from making the right decision, as in Schuett (2013). We compare two scenarios: one with no continuation rule and the other with a continuation rule. In the absence of the continuation rule, the applicant cannot have his application re-open once the examiner refuses a patent, even if a mistake was made. However, in the presence of the continuation rule, the applicant can decide to apply for continuation after a final rejection, which might rectify a mistake. Thus, from the USPTO viewpoint, allowing for continuation should help reduce mistakes of wrongly refusing a patent to a patentable innovation, which is a type I error (type II errors would be to wrongly grant a patent to a non-patentable innovation).

We find that the continuation rule introduces a trade-off for examiners: a reduction in the examination intensity of initial applications can compensate for the loss due to continuations in the case of rejections. Thus, examiners tend to reduce their examination efforts when ?>uncertainty about the innovation patentability is the highest. The existence of the continuation rule reduces examiners' incentives to make an effort to evaluate patent applications. Therefore, although the continuation rule might eliminate some mistakes (type I errors), it also reduces examiners' incentives to assess the innovation patentability (which might lead to type II errors). This is in line with Crémer (1995, 2010)'s findings that state that when a principal can choose between two types of monitoring technologies (one efficient that lowers the cost of acquiring information, and one inefficient that keeps the cost high), the principal might favor the inefficient one to increase the power of incentives. Here, the USPTO should prefer a patent process without continuation (which is inefficient because it could lead to more type I errors) to restore incentives to screen patent applications better (which reduces type II errors).

We also find that examiners tend to grant patents with little scrutiny when the innovation is more likely to be patentable, which reduces the likelihood of dealing with continuations later on. Overall, continuation reduces the examiners' incentive to perform in-depth evaluations and increases the grant rate. Abolishing continuing applications could restore examiners' incentives to thoroughly evaluate patent applications.

The U.S. patent continuation rule has often been criticized, which has led to discussions about its mere existence (Cotropia and Quillen, 2019).[5] Continuations seem to be used strategically to broaden the patent scope, although patents have not yet been granted (Lemley and Moore, 2004; Righi and Simcoe, 2020; Righi, Cannito, Vladasel, 2023). Continuations also allow

[5] Changes were initiated at the USPTO but eventually reversed. See, for instance, https://techtransfercentral.com/2009/10/14/uspto-rescinds-controversial-patent-rule-changes/

applicants to obtain patents, even after obtaining a final rejection. Therefore, patent examiners spend a fair amount of time on old patent applications rather than new ones. According to Cotropia and Quillen (2018), abolishing continuing applications could help the USPTO improve its management process, as it would free time for examiners to examine new applications. This result is consistent with our findings.

The remainder of this paper is organized as follows. In Section 2, we present the model. In Section 3, we analyze the case without continuation and derive equilibria. In section 4, we determine the equilibria in the continuation case. In Section 5, we compare the two cases, with and without continuation. Section 6 concludes.

2 The Model

We consider a model with two players: a patent applicant (A) and a patent examiner (E). At the outset, the applicant has an innovation whose patentability is unknown to both players. The innovation is either patentable ($\theta = 1$) with probability $\mu \in [0, 1]$ or not patentable ($\theta = 0$) with probability $1 - \mu$.[6] The applicant's first decision is to apply for a patent or not, formally $d_A = \{patent, not\}$. If she applies for a patent, she incurs a patenting cost C_P before the examiner receives her application. The examiner then makes a costly examination effort e which helps him obtain information about the innovation patentability. We assume that the effort generates a good or bad signal, $s \in S = \{good, bad\}$, such that $\Pr(s = good \mid \theta = 1, e) = \Pr(s = bad \mid \theta = 0, e) \equiv q(e) \in [1/2, 1]$ where $q'(e) > 0$. The higher the examiner's effort, the more likely he will find a piece of evidence in favor of granting a patent (a good signal when the innovation is more likely to be patentable) or in favor of rejecting (a bad signal when it is more likely it is not patentable).[7] The cost of examination effort $c(e)$ is such that $c'(e) > 0$ and $c''(e) \geq 0$. To simplify, we assume that $e \in \{0, 1\}$, and thus we denote $q(e) = q_e$ such that

[6] We do not consider the case where the applicant has better information about her innovation's patentability, which would complicate the model without changing the findings qualitatively.

[7] For a given level of effort, we assume that the examiner is as likely to obtain information to prove the non-patentability of the innovation (a negative signal) or the patentability of the innovation (a positive signal). This is a simplifying assumption. We could consider that, for the same level of effort, it is more likely that the examiner will find invalidating information. However, to keep our model simple, we make a symmetric assumption, which should not favor granting or rejecting.

$q(0) = q_0$ and $q(1) = q_1 > q_0$ with $c(0) = 0 < c(1) = c$.

After the examiner receives a signal s, he decides whether to grant a patent or not, formally $d_E = \{grant, reject\}$. In the case of a granting decision, the applicant obtains a patent and does not have to make another decision. However, if the patent application is rejected, the applicant can decide to apply for a continuation at cost C_c. We denote $d_{A|reject} = \{cont, nocont\}$ this applicant's second decision where $d_{A|reject} = cont$ corresponds to a continuation and $d_{A|reject} = nocont$ to a non-continuation (and thus to abandon the application without further consideration) after a rejection by the examiner.

If the applicant chooses $d_{A|reject} = cont$, the examiner receives the Request for Continued Examination (RCE), simply called continuation, and grants a patent with probability λ,[8] where $\lambda \in (0,1)$. Conditional on a continuation, the examiner's last decision is to grant or reject a patent, formally, $d_{E|cont} = \{grant, reject\}$, which is entirely determined by λ. To simplify, we assume that, at this stage, the rejection is final, and there is no possibility to continue further.[9] Continuation affects the examiner's utility as he gets fewer counts with subsequent continuations.

The timing of the game is the following. First, Nature chooses $\theta \in \{0, 1\}$. Second, the applicant decides to apply for a patent or not. If she does not apply for a patent ($d_A = not$), this is the end of the game. Third, if $d_A = patent$, the examiner receives an application, makes a costly examination effort $e \in \{0, 1\}$, and obtains a signal $s \in S$. Following the signal, the examiner decides to grant a patent or not. Fourth, in case of a rejection, the applicant decides whether to continue or not. Lastly, the examiner grants a patent or not, based on a random draw with probability λ.

For the applicant, the benefit from a non-patentable innovation that is not patented is normalized to 0, while it is $B > 0$ if she obtains a patent. A patentable innovation that is patented generates a benefit G if patented, and $\underline{G}$ if not patented, where $G > B > \underline{G} \geq 0$ as the applicant will get a higher payoff from a patentable innovation (it will not be invalidated in

[8] We could assume that depending on the initial effort $e \in \{0, 1\}$, the examiner grants a patent with probability λ_e, where $\lambda_0 \geq \lambda_1$. In that case, the higher the examiner's effort when he initially receives the application, the less likely he will grant a patent in case of continuation. However, to have a tractable model, we assume that $\lambda_0 = \lambda_1 = \lambda$. We could also assume that the quality of the application is higher when the applicant re-apply, which might make it easier to reach a decision for the examiner.

[9] This is a simplifying assumption. We could assume that several rounds of continuation are possible, which would complicate the model without changing the qualitative nature of the findings.

court), but she can still get some positive benefit from a patentable innovation that is rejected a patent.

If the applicant decides to apply for a patent, her net payoff is $\pi(\theta, d_E, d_{A|reject}, \lambda)$. If $\theta = 0$ it is

$$\pi(0, d_E, d_{A|reject}, \lambda) = \begin{cases} B & \text{if } d_E = grant\text{, for any } d_{A|reject} \text{ and } \lambda \\ 0 & \text{if } d_E = reject\text{, } d_{A|reject} = nocont\text{, and for any } \lambda \\ \lambda B - C_c & \text{if } d_E = reject\text{, } d_{A|reject} = cont\text{, and for any } \lambda \end{cases}$$

If $\theta = 1$, her net payoff is

$$\pi(1, d_E, d_{A|reject}, \lambda) = \begin{cases} G & \text{if } d_E = grant\text{, for any } d_{A|reject} \text{ and } \lambda \\ \underline{G} & \text{if } d_E = reject\text{, } d_{A|reject} = nocont\text{, and for any } \lambda \\ \lambda G + (1-\lambda)\underline{G} - C_c & \text{if } d_E = reject\text{, } d_{A|reject} = cont\text{, and for any } \lambda \end{cases}$$

We assume that $\lambda B < C_c < \lambda(G - \underline{G})$ and $B < C_P < G$.

The examiner's utility is $u(\theta, e, d_E, d_{A|reject}, d_{E|cont}) = S(\theta, d_E, d_{A|reject}, d_{E|cont}) - c(e)$, where his salary $S(.)$ for any $\theta \in \{0, 1\}$ is defined as follows[10]

$$S(\theta, d_E, d_{A|reject}, d_{E|cont}) = \begin{cases} s_g(\theta) & \text{if } d_E = grant\text{, for any } d_{A|reject} \text{ and } d_{E|cont} \\ s_r(\theta) & \text{if } d_E = reject\text{, } d_{A|reject} = nocont\text{, and for any } d_{E|cont} \\ s_{cont,g}(\theta) & \text{if } d_E = reject\text{, } d_{A|reject} = cont\text{, and } d_{E|cont} = grant \\ s_{cont,r}(\theta) & \text{if } d_E = reject\text{, } d_{A|reject} = cont\text{, and } d_{E|cont} = reject \end{cases}$$

When the applicant decides not to continue after a rejection, we assume that $s_g(1) > s_g(0)$ as it is possible that a granted non-patentable innovation might be randomly audited by the PTO and the patent case might be reopened, which would be detrimental to the examiner (while the case will never be reopened if the innovation is patentable). We denote $v_\theta \equiv s_g(\theta) - s_r(\theta)$ such

[10] This is a simplified version of the utility function. Indeed, a more complex utility function could be $u(\theta, e, d_E, d_{A|reject}, d_{E|cont}) = S(\theta, d_E) - c(e) + \delta Eu(d_E, d_{A|reject}, d_{E|cont})$, where the salary obtained for the current application would be $S(\theta, reject) = s_r^1(\theta)$ if rejected, $S(\theta, grant) = s_g^1(\theta)$ if granted, $Eu(grant, d_{A|reject}, d_{E|cont}) = EU(reject, noncont, d_{E|cont}) = EU$ would represent the expected utility from future decisions in the case of a non-continuation (in which case another application could be examined), $EU(reject, cont, grant) = s_{r,g}(\theta)$, and $EU(reject, cont, reject) = s_{r,r}(\theta)$ in the case of a continuation, and where δ is the discount factor. Here, we implicitly assume that $s_g(\theta) = S(\theta, grant) + \delta EU$, $s_r(\theta) = S(\theta, reject) + \delta EU$, $s_{cont,g}(\theta) = S(\theta, reject) + \delta s_{r,g}(\theta)$, and $s_{cont,r}(\theta) = S(\theta, reject) + \delta s_{r,r}(\theta)$.

that if $\theta = 1$, $v_1 = s_g(1) - s_r(1) \geq 0$ as the examiner can get some satisfaction (not necessarily monetary) from doing a good job, and if $\theta = 0$, $v_0 = s_g(0) - s_r(0) < 0$ as a granted patent on a non-patentable innovation can be reopened (while a rejected patent without continuation will not be pursued). To simplify, we use the notation $w_0 = -v_0$. We interpret v_1 (respectively, w_0) as the 'gain from making the right decision' when the innovation is patentable, $\theta = 1$ (respectively, not patentable, $\theta = 0$).[11] Finally, we also assume that $s_r(0) \geq s_r(1)$, as making the right decision (rejecting a patent to a non-patentable innovation) might bring more satisfaction to the examiner than wrongly granting a patent to a non-patentable innovation. It might be that the innovator has some suspicion that the innovation should not be patented but cannot find invalidating information.

When the applicant decides to continue after a rejection, similarly we assume that $s_{cont,g}(1) \geq s_{cont,r}(1)$, $s_{cont,r}(0) > s_{cont,g}(0)$. Further, we also assume that $s_{cont,g}(\theta) < s_g(\theta)$ and $s_{cont,r}(\theta) < s_r(\theta)$ for $\theta = \{0, 1\}$ as the salary of the examiner will be reduced after continuation as he obtains less counts.[12]

We further assume that the cost of effort c is not too large such that

$$c < \min(q_1 - q_0)\{v_1, v_1 - (\lambda s_{cont,g}(1) + (1 - \lambda)s_{cont,r}(1) - s_r(1)\}.$$

This assumption means that marginal cost of effort, $c - 0$, is smaller than the marginal gain from making the right decision when the innovation is patentable when there is no continuation $((q_1 - q_0)v_1)$ and when there is continuation $((q_1 - q_0)(v_1 - (\lambda s_{cont,g}(1) + (1 - \lambda)s_{cont,r}(1) - s_r(1)))$.

To solve the game, we use the concept of Perfect Bayesian Nash equilibrium. Using Bayes' rule, we denote $\mu_k = \Pr(\theta = 1 \mid s = k)$ where $k = \{good, bad\}$ so that (see Appendix A.1. for the detail of the calculations)

$$\mu_{good} = \frac{\mu q_e}{\mu q_e + (1 - \mu)(1 - q_e)}, \tag{1}$$

[11] It is the opportunity cost from granting (rejecting) a patent to a patentable (non-patentable) innovation.

[12] This would be consistent with the more complicated setting mentioned in Footnote 10. Consistent with the notations from Footnote 10, we have $s_g(\theta) = s_g^1(\theta) + \delta EU$, $s_r(\theta) = s_r^1(\theta) + \delta EU$, $s_{cont,g}(\theta) = s_r^1(\theta) + \delta s_{r,g}(\theta)$, and $s_{cont,r}(\theta) = s_r^1(\theta) + \delta s_{r,r}(\theta)$. If we assume that $EU \geq \min\{s_{r,g}(\theta), s_{r,r}(\theta)\}$, thus, for any θ we have $s_{cont,r}(\theta) \leq s_r(\theta)$ as $s_r^1(\theta) + \delta s_{r,r}(\theta) \leq s_r^1(\theta) + \delta EU$ is always satisfied. We also have $s_{cont,g}(1) \leq s_g(1)$ as $s_r^1(1) + \delta s_{r,g}(1) \leq s_g^1(1) + \delta EU$ is always satisfied. For $\theta = 0$, $s_{cont,g}(0) < s_g(0)$ if $s_r^1(0) + \delta s_{r,g}(0) < s_g^1(0) + \delta EU$ is satisfied, or if EU is large enough.

$$\mu_{bad} = \frac{\mu(1-q_e)}{\mu(1-q_e)+(1-\mu)q_e}. \tag{2}$$

We study, in turn, the case without continuation and the case with continuation. In the first case, the applicant cannot apply for a continuation and, thus, we only consider the applicant's decision to apply for a patent, the examiner's effort after receiving an application, and his decision to grant a patent or not after obtaining information from the examination process (which is the signal). In the second case, we consider that the applicant can decide to file for continuation after her patent application has been rejected, and we analyze how this possibility affects the previous findings.

3 No Continuation Rule

We first consider the case where there is no continuation,[13] in which case, the only decision of the applicant is to apply for a patent or not. If the applicant decides not to apply for a patent, the game ends with a null payoff and null utility for the applicant and the examiner. If the applicant decides to apply for a patent, the examiner receives the patent application and makes an effort $e \in \{0,1\}$ to evaluate it. After making an effort e, the examiner gets a signal $s = \{good, bad\}$ and must decide whether to grant a patent. If he receives a signal $s = bad$, his expected utility from choosing $d_E = reject$ is $\mu_{bad}u(1, e, reject, nocont, d_{E|cont}) + (1-\mu_{bad})u(0, e, reject, nocont, d_{E|cont})$ or, equivalently,

$$\mu_{bad}[s_r(1) - s_r(0)] + s_r(0) - c(e). \tag{3}$$

His expected utility from choosing $d_E = grant$ is $\mu_{bad}u(1, e, grant, nocont, d_{E|cont})$ $+(1-\mu_{bad})u(0, e, grant, nocont, d_{E|cont})$ or, equivalently,

$$\mu_{bad}[s_g(1) - s_g(0)] + s_g(0) - c(e). \tag{4}$$

After receiving the signal $s = bad$, he reports truthfully (i.e., he follows the signal, and thus chooses $d_E = reject$) if the expected utility (3) is higher than (4) or, equivalently, if $\mu_{bad} < w_0/(v_1 + w_0)$, where $v_1 = s_g(1) - s_r(1) \geq 0$ and $w_0 = s_r(0) - s_g(0) > 0$ as defined previously.

[13] We implicitly assume that a final rejection leads automatically to an abandonment of the patent application (i.e., $d_{A|reject} = nocont$).

Similarly, if he receives a signal $s = good$, his expected utility from choosing $d_E = grant$ is $\mu_{good} u(1, e, grant, nocont, d_{E|cont}) + (1 - \mu_{good}) u(0, e, grant, nocont, d_{E|cont})$ or, equivalently,

$$\mu_{good}[s_g(1) - s_g(0)] + s_g(0) - c(e). \tag{5}$$

His expected utility from choosing $d_E = reject$ is $\mu_{good} u(1, e, reject, nocont, d_{E|cont})$ $+ (1 - \mu_{good}) u(0, e, reject, nocont, d_{E|cont})$ or, equivalently,

$$\mu_{good}[s_r(1) - s_r(0)] + s_r(0) - c(e). \tag{6}$$

After receiving the signal $s = good$, he reports truthfully (i.e., he follows the signal and, thus, chooses $d_E = grant$) if his expected utility (5) is higher than (6) or, equivalently, if $\mu_{good} > w_0/(v_1 + w_0)$.

Thus, the examiner reports truthfully (i.e., follows the signal) if

$$\mu_{bad} < \frac{w_0}{v_1 + w_0} < \mu_{good}, \tag{7}$$

where μ_{good} and μ_{bad} are defined by (1) and (2), respectively. By replacing (1) and (2) in (7), we find that the examiner reports truthfully if $\mu \in]\underline{\mu}_{NC}(q_e), \overline{\mu}_{NC}(q_e)[$ where

$$\overline{\mu}_{NC}(q_e) \equiv \tfrac{w_0 q_e}{w_0 q_e + (1 - q_e) v_1}, \tag{8}$$

and

$$\underline{\mu}_{NC}(q_e) \equiv \tfrac{w_0 (1 - q_e)}{w_0 (1 - q_e) + q_e v_1}. \tag{9}$$

When he receives the application to review, the examiner must choose an effort level $e \in \{0, 1\}$. Conditional on reporting truthfully as defined above, his expected utility for any e is

$$q_e[\mu(v_1 - w_0) + w_0] + (1 - \mu) s_g(0) + \mu s_r(1) - c(e).$$

Therefore, the examiner chooses to make a positive effort ($e = 1$) rather than no effort ($e = 0$) if

$$q_1[\mu(v_1 - w_0) + w_0] + (1 - \mu) s_g(0) + \mu s_r(1) - c > q_0[\mu(v_1 - w_0) + w_0] + (1 - \mu) s_g(0) + \mu s_r(1),$$

which simplify to $(q_1 - q_0)(\mu(v_1 - w_0) + w_0) > c$, meaning that the expected gain from making a positive effort must exceed the cost of effort. As $q_1 > q_0$, this is equivalent to

$$\mu(v_1 - w_0) \geq \tfrac{c}{q_1 - q_0} - w_0. \tag{10}$$

If $v_1 > w_0$, inequality (10) is equivalent to having $\mu \geq \mu_{NC}$ with

$$\mu_{NC} \equiv \tfrac{1}{v_1 - w_0}(\tfrac{c}{q_1 - q_0} - w_0). \tag{11}$$

Thus, as long as $0 < \mu_{NC} < 1$, i.e., $w_0(q_1 - q_0) < c < v_1(q_1 - q_0)$, the examiner makes a positive effort ($e = 1$) if $\mu \geq \mu_{NC}$. If $v_1 < w_0$, as we assume that $c < (q_1 - q_0)v_1$, we have that $c < w_0(q_1 - q_0)$, and thus, the examiner makes a positive effort ($e = 1$) for any $\mu \in [0, 1]$.[14] We posit the following Lemma.

Lemma 1 *Conditional on reporting truthfully, i.e., if $\mu \in]\underline{\mu}_{NC}(q_e), \overline{\mu}_{NC}(q_e)[$ with $\underline{\mu}_{NC}(q_e)$ and $\overline{\mu}_{NC}(q_e)$ defined by (8) and (9), respectively, the examiner makes*

- *no effort ($e^* = 0$) if $\mu < \mu_{NC}$, for $v_1 > w_0$; and*
- *a positive effort ($e^* = 1$) if $\mu \geq \mu_{NC}$ for $v_1 > w_0$, or for any $\mu \in [0, 1]$ for $v_1 < w_0$.*

Proof. Follows from the above discussion. ■

Recall that v_1 represents the gain from making the right decision when the innovation is patentable, while w_0 represents the gain from making the right decision when the innovation is non patentable. When $w_0 < v_1$, we have $s_r(0) - s_g(0) < s_g(1) - s_r(1)$ or, equivalently, $s_r(0) + s_r(1) < s_g(1) + s_g(0)$. Thus, the examiner will be better off by granting a patent and when it is more likely that the innovation is non-patentable (for $\mu < \mu_{NC}$) the examiner would prefer not to get an informative signal. On the other hand, when $\mu \geq \mu_{NC}$, the reverse occurs.

However, when $v_1 < w_0$, the gain from making the right decision when the innovation is non-patentable is larger than the gain from patenting. Thus, the examiner makes more effort to search for information.

At the outset, anticipating this optimal level of effort e^*, the applicant decides to apply for a patent if $\mu[q_{e^*}(G - \underline{G} + B) + \underline{G} - B] + (1 - q_{e^*})B - C_P > 0$, or if $\mu \geq \mu_P(q_{e^*})$ with

$$\mu_P(q_{e^*}) \equiv \tfrac{C_P - (1 - q_{e^*})B}{q_{e^*}(G - \underline{G} + B) + \underline{G} - B}. \tag{12}$$

Thus, if $e^* = 1$, the applicant applies for a patent if $\mu > \mu_P(q_1)$. If $e^* = 0$, the applicant applies for a patent if $\mu > \mu_P(q_0)$, where $\mu_P(q_0) > \mu_P(q_1)$.

We summarize these findings in the following Proposition.

[14] Similar results would also be found for $c > v_1(q_1 - q_0)$.

Proposition 1 (No continuation rule) *If* $\mu \in [\max\{\mu_P(q_{e^*}), \underline{\mu}_{NC}(q_{e^*})\}, \overline{\mu}_{NC}(q_{e^*})]$, *there exists a Perfect Bayesian Nash equilibrium in which*

- *the applicant always applies for a patent ($d_A = patent$);*
- *the examiner makes an effort $e^* = 1$ (resp., $e^* = 0$) if $\mu \geq \mu_{NC}$ (resp., $\mu < \mu_{NC}$);*
- *the examiner reports truthfully such that his beliefs on θ are μ_{good} and μ_{bad}, and $d_E(good) = grant$ and $d_E(bad) = reject$;*
- *the applicant's beliefs are $\Pr(s = bad \mid d_E = reject) = \Pr(s = good \mid d_E = grant) = 1$ and $\Pr(\theta = 1 \mid d_E = grant) = \mu_{good}$ and $\Pr(\theta = 1 \mid d_E = reject) = \mu_{bad}$.*

Proof. Follows from the above discussion. ■

Thus, in the absence of continuation, for intermediate values of μ, the examiner always reports the signal obtained after searching for information.

Other equilibria exist in which the applicant always applies for a patent, the examiner makes no effort and always grants a patent (for $\mu > \max\{\overline{\mu}_{NC}(q_{e^*}), \mu_P(q_{e^*})\}$), or in which the applicant never applies for a patent (for $\mu < \mu_P(q_{e^*})$). We summarize these findings in the following Proposition.

Proposition 2 *There exist Perfect Bayesian Nash equilibria in which the examiner does not reveal truthfully as follows:*

- *if $\mu > \overline{\mu}_{NC}(q_{e^*})$,*
  - *the applicant applies for a patent ($d_A = patent$) if $\mu > (C_P - B)/(G - B)$;*
  - *the examiner makes no effort ($e^* = 0$), and always grant a patent;*
- *if $\mu < \mu_P(q_{e^*})$, the applicant never applies for a patent ($d_A = not$).*

Proof. See Appendix A.2. ■

We represent the different equilibria in a graph (w_0, μ) in Figure 1. Recall that $w_0 = s_r(0) - s_g(0)$ represents the examiner's gain from making the right decision when the innovation is not patentable, and μ is the probability that the innovation is patentable. The function μ_{NC} expressed by (11) separates the areas where the examiner makes an effort $e = 0$ and an effort $e = 1$ when he reports truthfully for $\mu \in [\underline{\mu}_{NC}(q_{e^*}), \overline{\mu}_{NC}(q_{e^*})]$, where $\overline{\mu}_{NC}(q_{e^*})$ and $\underline{\mu}_{NC}(q_{e^*})$ are expressed by (8) and (9) respectively, for q_0 and q_1. Lastly, the applicant applies for a patent if $\mu > \mu_P(q_{e^*})$ where $\mu_P(q_{e^*})$ is defined by (12).

Four different areas are represented in Figure 1. For low values of w_0, the applicant applies for a patent if μ is not too small, the examiner makes no effort and always grants a patent (Area **(I)**). As w_0 increases, for small values of μ, the applicant does not apply for a patent (Area **(II)**). For higher values of μ, she does apply for a patent, and the examiner makes no effort (Area **(III)**) or makes a positive effort and reports truthfully (Area **(IV)**).

Thus, for intermediate values of μ, starting from intermediate values of w_0 (the applicant applies for a patent, the examiner makes an effort $e^* = 1$, and reports truthfully, point A in Area **(IV)** in Figure 1), a marginal decrease in w_0 leads to less effort from the examiner, even though he still reports truthfully (the applicant applies for a patent, the examiner makes an effort $e = 0$, and reports truthfully, point B in Area **(III)**). As w_0 decreases further, we reach an area where the applicant applies for a patent, the examiner makes no effort and always grants a patent (point C in Area **(I)**). Thus, *ceteris paribus*, reducing the examiner's reward for making the right decision when the innovation is not patentable (i.e., decreasing w_0) induces less effort and increases (wrong) patenting. For smaller values of μ, a reduction in w_0 can even induce the innovator not to apply for a patent (Area **(II)**), which reduces patenting.

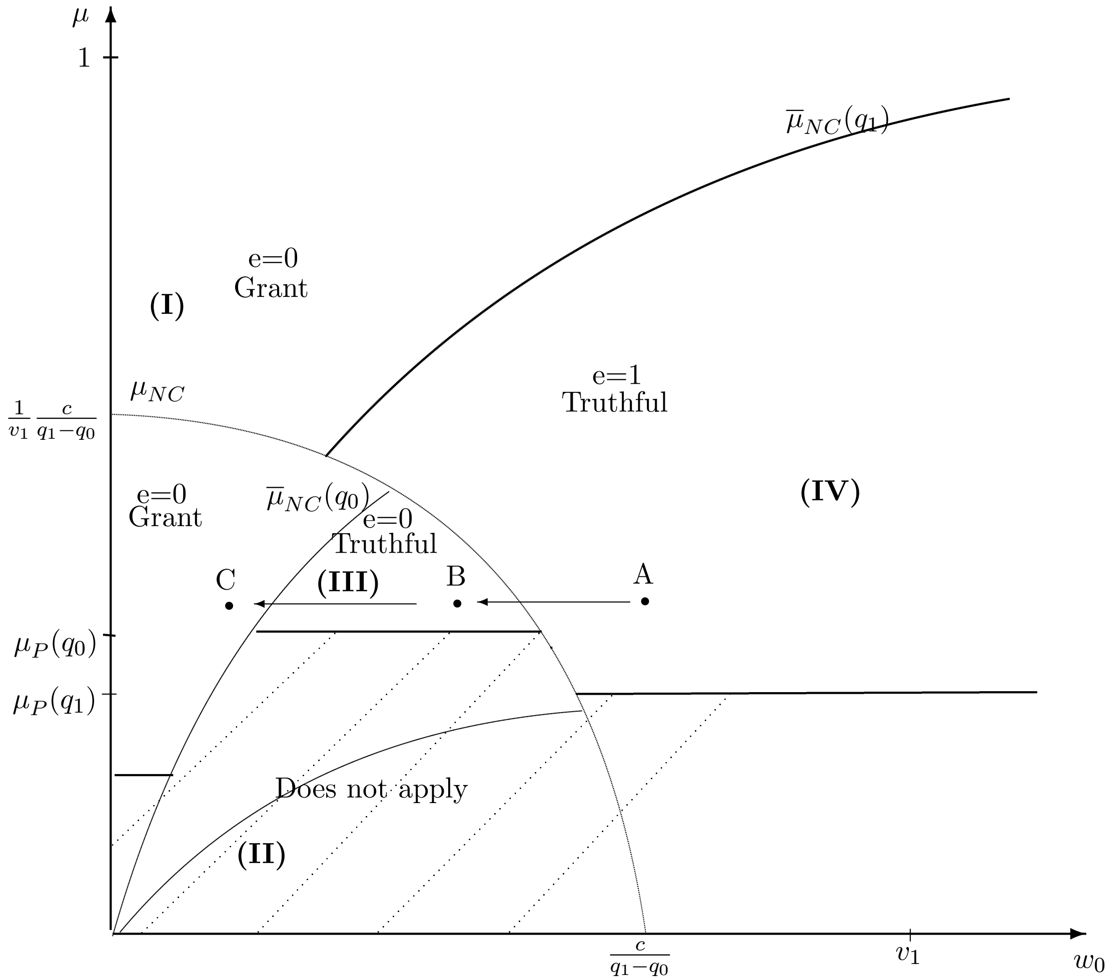

Figure 1: No Continuation rule for $c \leq v_1(q_1 - q_0)$

We state the following Corollary.

Corollary 1 *For intermediate values of μ and w_0, ceteris paribus, a marginal decrease in w_0 leads to less examination effort, which might induce more type II errors (granting patents to non-patentable innovations).*

This result suggests that, for the highest level of uncertainty of innovations' patentability (for intermediate values of μ), it might be beneficial to slightly increase the examiner's reward for making the right decision when the innovation is not patentable or to decrease the examiner's salary for making the wrong decision $s_g(0)$. In other words, 'punishing' the examiner could induce a higher effort level.

4 Continuation Rule

We now consider the case where the applicant can decide to submit a continuation after her patent has been rejected. Like in the previous case, at the outset, if the applicant decides to apply for a patent, the examiner receives the patent application and makes an effort $e \in \{0, 1\}$ to evaluate it. After making an effort e, the examiner obtains a signal $s = \{good, bad\}$ and must decide to grant a patent or not. Thus, an examiner who receives a signal $s = bad$, and chooses $d_E = reject$ gets the following expected utility

$$\begin{aligned} EU_{bad}(reject, d_{A|reject}, d_{E|cont}) &= \mu_{bad} u(1, e, reject, d_{A|reject}, d_{E|cont}) \\ &\quad + (1 - \mu_{bad}) u(0, e, reject, d_{A|reject}, d_{E|cont}), \end{aligned}$$

which depends on the applicant's decision after a rejection, $d_{A|reject}$. An examiner who receives a signal $s = bad$, and chooses $d_E = grant$ gets the following expected utility

$$EU_{bad}(grant) = \mu_{bad} u(1, e, grant, nocont, d_{E/cont}) + (1 - \mu_{bad}) u(1, e, grant, noncont, d_{E/cont}),$$

or, equivalently, $EU_{bad}(grant) = \mu_{bad} s_g(1) + (1 - \mu_{bad}) s_g(0) - c(e)$.

Sequential optimality implies truthful revelation if

$$EU_{bad}(reject, d_{A|reject}, d_{E|cont}) > EU_{bad}(grant). \tag{13}$$

An examiner who receives a signal $s = good$, and chooses $d_E = grant$ gets the following expected utility

$$\begin{aligned} EU_{good}(grant) &= \mu_{good} u(1, e, grant, noncont, d_{E/cont}) + (1 - \mu_{good}) u(1, e, grant, nocont, d_{E/cont}) \\ &= \mu_{good} s_g(1) + (1 - \mu_{good}) s_g(0) - c(e). \end{aligned}$$

An examiner who receives a signal $s = good$, and chooses $d_E = reject$ gets the following expected utility

$$\begin{aligned} EU_{good}(reject, d_{A|reject}, d_{E|cont}) &= \mu_{good} u(1, e, reject, d_{A|reject}, d_{E|cont}) \\ &\quad + (1 - \mu_{good}) u(0, e, reject, d_{A|reject}, d_{E|cont}). \end{aligned}$$

Sequential optimality implies truthful revelation if

$$EU_{good}(grant) > EU_{good}(reject, d_{A|reject}, d_{E|cont}). \tag{14}$$

The applicant does not know whether her innovation is patentable. Once she has applied for a patent and the examination process has been completed, she only observes that the patent has been rejected or granted. After her application has been rejected ($d_E = reject$), if she knew θ, she would apply for continuation if her innovation was patentable and would not continue if it was not patentable. Indeed, if $\theta = 1$, she would apply for continuation ($d_{A|reject} = cont$) as $\lambda G + (1-\lambda)\underline{G} - C_c > 0$ is always satisfied as by assumption $\lambda(G - \underline{G}) > C_c$, and if $\theta = 0$, she would not apply for continuation ($d_{A|reject} = nocont$) as $\lambda B < C_c$, which is always satisfied by assumption. However, she does not know θ, and only observes that a patent has been rejected. Let denote $\Pr(\theta = 1 \mid d_E = reject) \equiv \widetilde{\mu}$. If the applicant chooses to continue ($d_{A|reject} = cont$) after her patent has been rejected, she obtains

$$\widetilde{\mu}(\lambda G + (1-\lambda)\underline{G} - C_c) + (1-\widetilde{\mu})(\lambda B - C_c).$$

If she does not continue ($d_{A|reject} = nocont$), she gets $\widetilde{\mu}\underline{G}$. Thus, she decides to continue ($d_{A|reject} = cont$) as long as $\widetilde{\mu}(\lambda G + (1-\lambda)\underline{G} - C_c) + (1-\widetilde{\mu})(\lambda B - C_c) > \widetilde{\mu}\underline{G}$, or, equivalently, if

$$\widetilde{\mu} > \frac{C_c - \lambda B}{\lambda(G - \underline{G} - B)}, \tag{15}$$

where $G - \underline{G} > B$ and $C_c > \lambda B$ are satisfied by assumption. Thus, if inequality (15) is satisfied, the applicant always continues ($d_{A|reject} = cont$) after her patent has been rejected. In that case, we can rewrite (13) and (14) as

$$\mu_{bad}(v_1^{cont} + v_0^{cont}) \leq v_0^{cont} < \mu_{good}(v_1^{cont} + v_0^{cont}),$$

where

$$v_1^{cont} = v_1 - \Phi_a, \tag{16}$$

with $\Phi_a = -s_r(1) + (\lambda s_{cont,g}(1) + (1-\lambda)s_{cont,r}(1))$, and

$$v_0^{cont} = w_0 - \Phi_b, \tag{17}$$

with $\Phi_b = s_r(0)-(\lambda s_{cont,g}(0)+(1-\lambda)s_{cont,r}(0))$. We show that $v_1^{cont} > 0$ even though v_1^{cont} can be larger or smaller than v_1, while $v_0^{cont} < w_0$, and $v_0^{cont} > 0$ as long as $w_0 > \Phi_b$ (see Appendix A.3.). Notice that the assumption on the cost of effort can be rewritten as $c < \min(q_1 - q_0)\{v_1, v_1^{cont}\}$.

We can rewrite (13) and (14) as

$$\mu_{bad} \leq \frac{v_0^{cont}}{v_1^{cont} + v_0^{cont}} < \mu_{good}. \tag{18}$$

Therefore, the examiner reveals truthfully if (18) is satisfied or, equivalently, if $\underline{\mu}_C(q_e) < \mu \leq \overline{\mu}_C(q_e)$ with

$$\underline{\mu}_C(q_e) \equiv \frac{(1-q_e)v_0^{cont}}{(1-q_e)v_0^{cont}+q_e v_1^{cont}}, \tag{19}$$

and

$$\overline{\mu}_C(q_e) \equiv \frac{q_e v_0^{cont}}{q_e v_0^{cont}+(1-q_e)v_1^{cont}}. \tag{20}$$

We verify that $\underline{\mu}_C(q_0) > \underline{\mu}_C(q_1)$ and $\overline{\mu}_C(q_0) < \overline{\mu}_C(q_1)$ with $q_0 < q_1$. Thus, for $\underline{\mu}_C(q_e) < \mu \leq \overline{\mu}_C(q_e)$, the examiner reveals truthfully the signal he received and the applicant always continues after her patent has been rejected if (15) is satisfied. In equilibrium, $\widetilde{\mu} = \mu_{bad}$ and, thus, (15) is equivalent to having $\mu > \overline{\mu}_A(q_e)$ where

$$\overline{\mu}_A(q_e) \equiv \frac{q_e(C_c-\lambda B)}{q_e(C_c-\lambda B)+(1-q_e)(\lambda(G-\underline{G})-C_c)}, \tag{21}$$

with $\overline{\mu}_A(q_0) < \overline{\mu}_A(q_1) < 1$.

When he receives the application to evaluate, the examiner must choose his effort level $e \in \{0, 1\}$. Conditional on reporting truthfully and that the applicant continues after a rejection ($d_{A|reject} = cont$) if $\mu > \overline{\mu}_A(q_e)$, the examiner's expected utility for any e is

$$q_e[\mu(v_1^{cont} - v_0^{cont}) + v_0^{cont}] + (1-\mu)s_g(0) + \mu(s_g(1) - v_1^{cont}) - c(e).$$

Hence, the examiner makes an effort $e = 1$ if $q_1[\mu(v_1^{cont} - v_0^{cont}) + v_0^{cont}] + (1-\mu)s_g(0) + \mu(s_g(1) - v_1^{cont}) - c \geq q_0[\mu(v_1^{cont} - v_0^{cont}) + v_0^{cont}] + (1-\mu)s_g(0) + \mu(s_g(1) - v_1^{cont})$ or, equivalently, if

$$\mu(v_1^{cont} - v_0^{cont}) \geq \frac{c}{q_1 - q_0} - v_0^{cont}. \tag{22}$$

Similar to the no continuation rule case, we define

$$\mu_C \equiv \frac{1}{v_1^{cont}-v_0^{cont}}\left(\frac{c}{q_1-q_0} - v_0^{cont}\right), \tag{23}$$

which can be either positive (if $v_0^{cont} < \min\{v_1^{cont}, c/(q_1-q_0)\}$ or if $v_0^{cont} > \max\{v_1^{cont}, c/(q_1-q_0)\}$) or negative (if $c/(q_1-q_0) < v_0^{cont} < v_1^{cont}$). Also, $\mu_C \leq 1$ as $v_1^{cont} \geq c/(q_1-q_0)$ by assumption.

If $v_1^{cont} > v_0^{cont}$, inequality (22) is equivalent to having $\mu \geq \mu_C$ (regardless of whether $\mu_C \geq 0$ or $\mu_C < 0$, as long as $\mu_C \leq 1$) and, thus, the examiner always makes an effort $e = 1$. However, if $\mu < \mu_C$ (as long as $\mu_C > 0$), the examiner makes no effort. On the other hand, if $v_1^{cont} < v_0^{cont}$, inequality (22) is equivalent to having $\mu \leq \mu_C$ (as long as $\mu_C > 0$) and, thus, the examiner always makes an effort $e = 1$. However, if $\mu > \mu_C$ (regardless of whether $\mu_C \leq 0$ or $\mu_C > 0$, as long as $\mu_C \leq 1$), the examiner makes no effort.

We summarize the different situations in which the examiner chooses the effort levels in the following Lemma (which is equivalent to Lemma 1).

Lemma 2 *Conditional on reporting truthfully (i.e., if $\mu \in]\underline{\mu}_C, \overline{\mu}_C[$), if $\mu > \overline{\mu}_A(q_e)$ (in which case the applicant decides to continue after a rejection),*

- *for $v_1^{cont} > v_0^{cont}$, the examiner makes no effort ($e^* = 0$) for $\mu < \mu_C$, and makes the effort $e^* = 1$ for $\mu \geq \mu_C$;*
- *for $v_1^{cont} < v_0^{cont}$, the examiner always makes an effort $e^* = 1$ for any $\mu \in [0, 1]$.*

Proof. Follows from the above discussion. ■

At the outset, for a given level of effort e^* chosen by the examiner, the applicant decides to apply for a patent if

$$\mu[q_{e^*}\pi(1, grant, nocont, \lambda) + (1-q_{e^*})\pi(1, reject, cont, \lambda)]$$
$$+(1-\mu)[(1-q_{e^*})\pi(0, grant, nocont, \lambda) + q_{e^*}\pi(0, reject, cont, \lambda)] - C_P > 0,$$

or, equivalently, if $\mu \geq \mu_{CP}(q_{e^*})$ where

$$\mu_{CP}(q_{e^*}) \equiv \frac{C_P-(1-q_{e^*})B+q_{e^*}(C_c-\lambda B)}{q_{e^*}(C_c-\lambda B+G)+(1-q_{e^*})(\lambda(G-\underline{G})-C_c-(B-\underline{G}))}. \tag{24}$$

We show that $\mu_{CP}(q_0) < \mu_{CP}(q_1)$, and $\mu_{CP}(q_{e^*}) < \overline{\mu}_A(q_{e^*})$ if C_P is small enough. Thus, if $e^* = 1$ (which occurs for $\mu \geq \mu_C$ if $v_1^{cont} > v_0^{cont}$ or for any μ if $v_0^{cont} \geq v_1^{cont}$), the applicant applies for a patent if $\mu > \mu_{CP}(q_1)$. If $e^* = 0$ (which occurs for $\mu < \mu_C$), the applicant applies for a patent if $\mu > \mu_{CP}(q_0)$.

We summarize these findings in the following Proposition.

Proposition 3 (Continuation) *If $\mu \in [\max\{\mu_{CP}(q_{e^*}), \overline{\mu}_A(q_e)\}, \overline{\mu}_C(q_{e^*})]$, there exists a Perfect Bayesian Nash equilibrium in which*

- *the applicant always applies for a patent ($d_A = patent$);*
- *the examiner makes an effort $e^* = 1$ (resp., $e^* = 0$) if $\mu \geq \mu_C$ (resp., $\mu < \mu_C$);*
- *the examiner reports truthfully such that his beliefs on θ are μ_{good} and μ_{bad}, and $d_E(good) = grant$ and $d_E(bad) = reject$;*
- *the applicant's beliefs are $\Pr(s = bad \mid d_E = reject) = \Pr(s = good \mid d_E = grant) = 1$ and $\Pr(\theta = 1 \mid d_E = grant) = \mu_{good}$ and $\Pr(\theta = 1 \mid d_E = reject) = \mu_{bad}$.*
- *The applicant files for a continuation ($d_{A|reject} = cont$) after her patent application has been rejected.*

Proof. Follows from the above discussion. ■

There exist other equilibria. Consider now that (15) is not satisfied. Thus, the applicant never continues ($d_{A/reject} = nocont$) after her patent has been rejected. In that case, we rewrite (13) and (14) as $\mu_{bad} < w_0/(v_1+w_0) < \mu_{good}$, with $v_1 = s_g(1)-s_r(1) \geq 0$ and $w_0 = s_r(0)-s_g(0) > 0$ as defined in the case of the no continuation rule. Therefore, the examiner reveals the truth as long as $\mu_{bad} < w_0/(v_1 + w_0) < \mu_{good}$ or, equivalently, if $\underline{\mu}_{NC} < \mu < \overline{\mu}_{NC}$ and the applicant does not continue after her patent has been rejected if (15) is not satisfied. In equilibrium, $\widetilde{\mu} = \mu_{bad}$ and thus $\mu < \overline{\mu}_A$.

When he gets the application, the examiner must choose the effort level $e \in \{0, 1\}$. Conditional on reporting truthfully and that the applicant does not continue after a rejection ($d_{A/reject} = nocont$) if $\mu < \overline{\mu}_A$, his expected utility for any e is

$$q(e)(\mu(v_1 - w_0) + w_0) + (1 - \mu)s_g(0) + \mu s_r(1) - c(e).$$

Hence, the examiner makes the effort $e^* = 1$ if

$$\mu(v_1 - w_0) > \frac{c}{q_1 - q_0} - w_0.$$

If $v_1 > w_0$, it is equivalent to having $\mu > \mu_{NC}$. If $v_1 < w_0$, then the examiner always makes an effort $e^* = 0$.

At the outset, for any e^* the applicant decides to apply for a patent if

$$\mu[q_{e^*}\pi(1, grant, nocont, 0, \lambda) + (1 - q_{e^*})\pi(1, reject, nocont, \lambda)]$$
$$+(1 - \mu)[(1 - q_{e^*})\pi(0, grant, nocont, \lambda) + q_{e^*}\pi(0, reject, nocont, \lambda) - C_P,$$

or, equivalently, if $\mu > \mu_P(q_{e^*})$ as defined by (12).

Thus, if $\underline{\mu}_{NC} < \mu < \overline{\mu}_A$, and $v_1^{cont} > v_0^{cont}$, there exists a Perfect Bayesian Nash equilibria which is the one represented in Proposition 1 where the applicant does not file for a continuation ($d_{A|reject} = nocont$) after her patent application has been rejected.

There exist other equilibria in which the applicant always applies for a patent, the examiner makes no effort and always grants a patent (for $\mu > \max\{\overline{\mu}_C(q_{e^*}), \mu_{CP}(q_{e^*})\}$), or in which the applicant never applies for a patent (for $\mu < \underline{\mu}_C(q_{e^*})$). We summarize these findings in the following Proposition.

Proposition 4 *There exist Perfect Bayesian Nash equilibria in which the examiner does not reveal truthfully as follows:*

- *If* $\mu > \overline{\mu}_C(q_{e^*})$,
  - *the applicant applies for a patent* ($d_A = patent$) *if* $\mu > \mu_{CP}$;
  - *the examiner makes no effort* ($e^* = 0$), *and always grants a patent.*
- *If* $\mu < \mu_{CP}(q_{e^*})$, *the applicant never applies for a patent* ($d_A = not$).

Proof. See Appendix A.3. ■

We represent the different equilibria in a graph (w_0, μ) in Figure 2. Although we represent all the functions and areas in function of w_0, recall that $v_0^{cont} = w_0 - s_r(0) + \lambda s_{cont,g}(0) + (1 - \lambda)s_{cont,r}(0)$, and $w_0 = s_r(0) - s_g(0)$. Thus, when we consider a change in w_0 we implicitly set $s_r(0)$ and we vary $s_g(0)$, as a change in $s_r(0)$ will impact both w_0 and v_0^{cont}. Thus, here, a decrease in w_0 means an increase in $s_g(0)$. Similar to the no continuation rule case, function (23) separates the areas where the examiner makes an effort $e = 0$ and an effort $e = 1$ when he reports truthfully. Functions (20) and (19) are represented for q_0 and q_1. The applicant applies for a patent if $\mu > \mu_P(q_{e^*})$ where $\mu_P(q_{e^*})$ is defined by (24). However, in the case of continuation, there are other functions that separate the applicant's decision to continue and not to continue, depending on whether the effort is $e = 0$ or $e = 1$ that is represented by (21).

For intermediate values of μ, starting from intermediate values of w_0, a marginal decrease in w_0, or, equivalently, a marginal increase in $s_g(0)$ (situation in which the applicant applies for a patent, the examiner makes an effort $e = 1$ and reports truthfully, and the applicant does not continue after a rejection, represented by point A in Figure 2) leads to less effort from the examiner, and the applicant continues after a rejection (point B). As in the no continuation rule case, as w_0 decreases further (or $s_g(0)$ increases), we reach an area where the applicant applies for a patent, the examiner makes no effort and always grants a patent (point C). Thus, rewarding less the examiner for making the right decision (i.e., decreasing w_0 or increasing $s_g(0)$, which is equivalent to increasing the reward for making an error), induces less effort and increases the likelihood of continuing after a rejection.

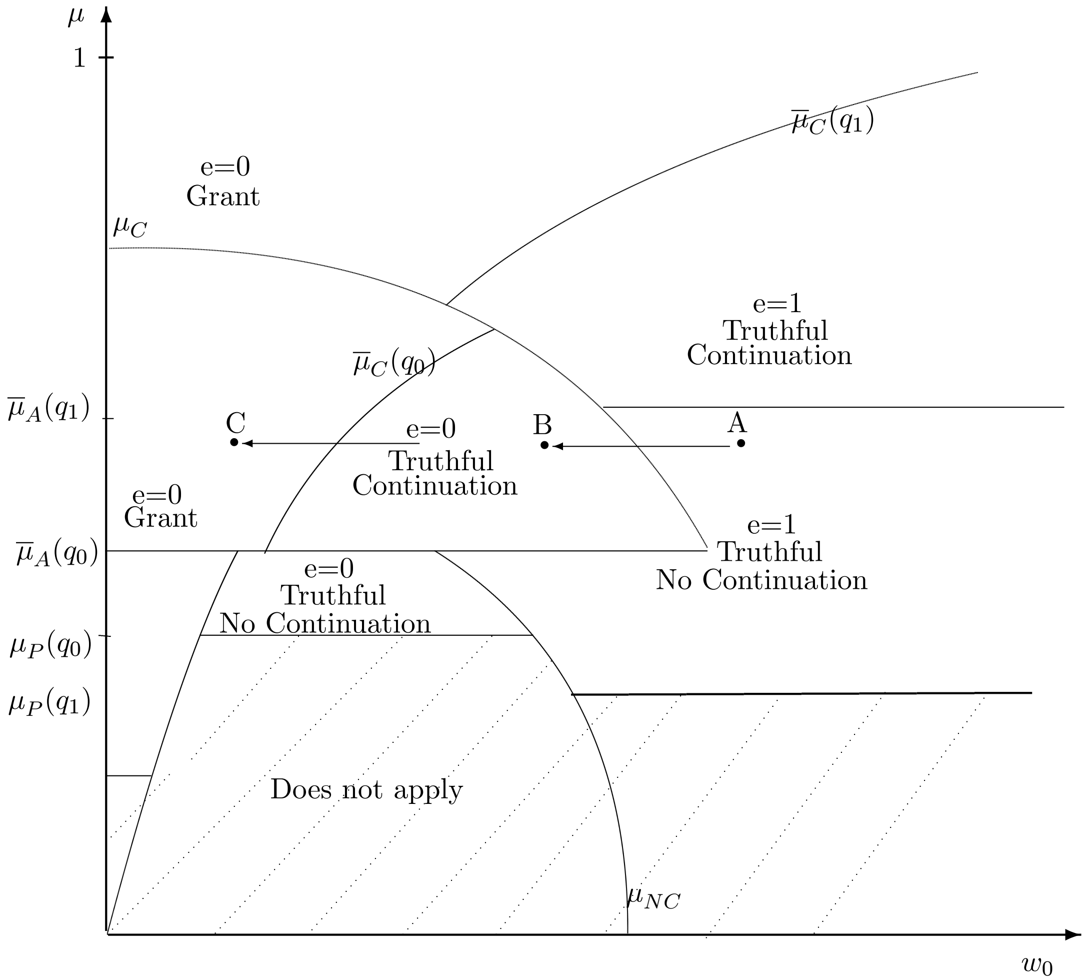

Figure 2: Continuation rule for $c \leq v_1^{cont}(q_1 - q_0)$

We state the following Corollary.

Corollary 2 *For intermediate values of μ and w_0, a marginal decrease of w_0 leads to less examination effort and more continuation, which might induce more type II errors (granting patents to non-patentable innovations).*

This result suggests that, *ceteris paribus*, increasing the examiner's salary for making a wrong decision (i.e., granting a patent to a non-patentable innovation), or reducing the gain from making the right decision when the innovation is not patentable, induces the examiner to reduce his effort to evaluate the application, which induces the applicant to apply for continuation when her application has been rejected a patent.

5 Comparison: Continuation versus No Continuation

We now compare the continuation and no continuation rules. To do so graphically, we combine both Figures 1 and 2 together in order to obtain Figure 3 (formal proofs are provided in Appendix A.4.).

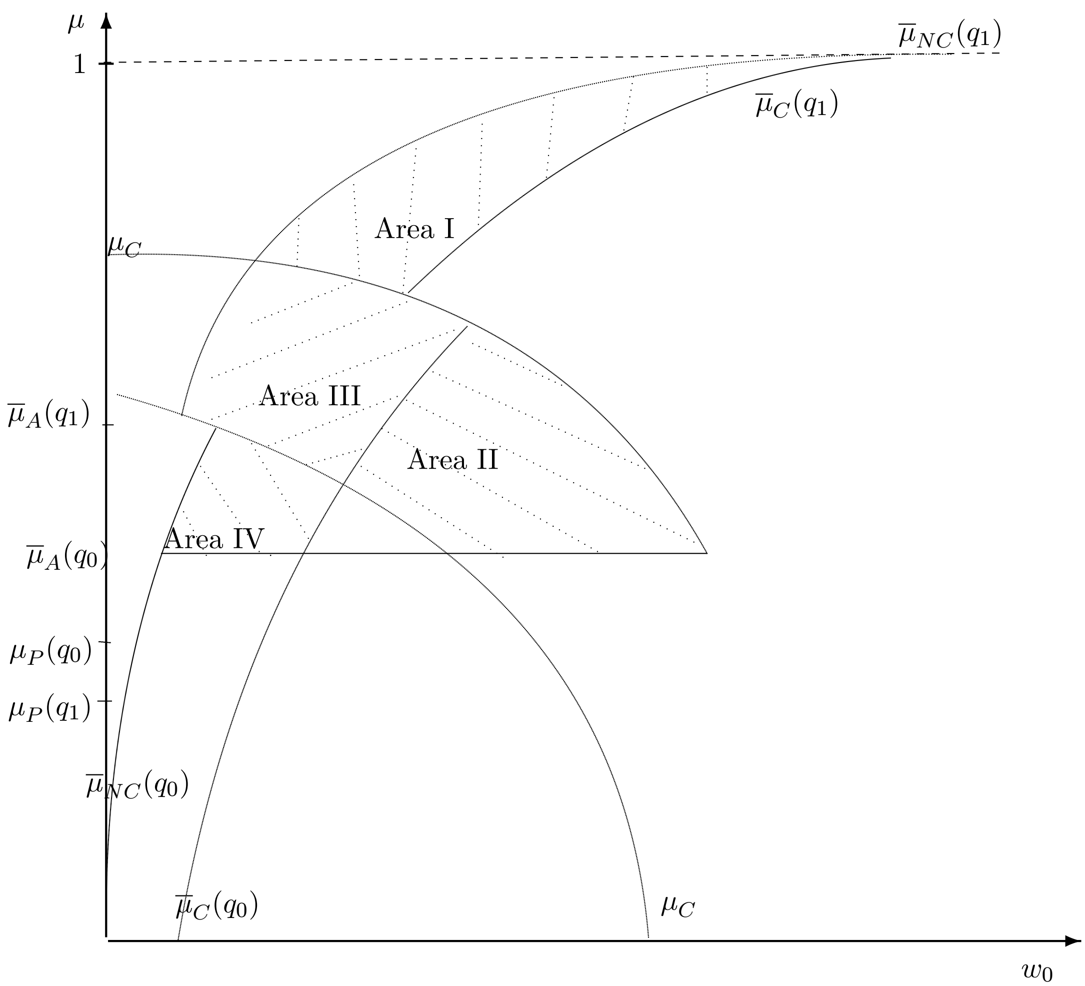

Figure 3: Comparison of continuation and no continuation rules for $c \leq v_1^{cont}(q_1 - q_0)$

In Areas I and III in Figure 3, in the absence of the continuation rule, the examiner makes an effort $e = 1$ and reports truthfully, while with the continuation rule, he does not make any effort and always grants a patent. In Area II, in the absence of the continuation rule, the examiner makes an effort $e = 1$ and reports truthfully, while with the continuation rule, the examiner makes no effort but still reports truthfully. Lastly, in Area IV, in the absence of the continuation rule, the examiner makes no effort and reports truthfully, while with the continuation rule, the examiner makes no effort and always grants a patent. We summarize these findings in the following Proposition.

Proposition 5 *The presence of the continuation rule reduces the examiner's effort and reduces the likelihood that the examiner will report truthfully.*

In other words, having the continuation rule reduces the range of parameters for which the examiner reports truthfully: in equilibrium, less truthful revelation occurs when the continuation rule exits. Furthermore, the possibility of continuation leads the examiner not to follow the signal more often than in the absence of continuation. The examiner has less incentive to report truthfully.

Following these findings, we then posit the following Corollary.

Corollary 3 *In the presence of the continuation rule, the examiner is more likely to grant a patent to a non-patentable innovation.*

The continuation rule, which is supposed to help reduce type I errors (reject a patent to a patentable innovation), increases the occurrence of type II errors (grant a patent to a non-patentable innovation). In our model, we do not quantify which errors are more harmful than the other. However, in the current patent system, when a patent application has been rejected, the applicant can still reapply for another patent (with a new case and a different patent examiner). On the other hand, when a patent has been wrongly granted to a non-patentable innovation, a costly patent infringement can rectify the mistake. Therefore, it seems that type I errors might be less costly to rectify than type II errors.

The applicant is more likely to apply for a continuation after a rejection for intermediate high values of μ. However, the applicant's decision to apply for a patent is not affected by the presence of the continuation rule, as summarized in the following Corollary.

Corollary 4 *The applicant will file for continuation after her patent has been rejected for intermediate values of μ. Whether there is a continuation rule or not does not affect the applicant's decision to apply for a patent.*

In this model, the only effect of the continuation rule on the applicant's behavior is on her ability to obtain a patent more often than without continuation.

To summarize, the continuation rule might lead to less patent examination effort and more grants, which will increase the occurrence of type II errors. In order to reduce this type of error, the USPTO could decide to change the award system of patent examiners and somehow punish them for making mistakes. Alternatively, without changing the award system of patent examiners, by abolishing the continuation rule, the USPTO could achieve the same result as providing more incentive: increase the examiners' effort and reduce the mistakes of granting patents to non-deserving innovations. In that sense, the continuation rule and the reward system (increasing the examiners' rewards in case of a good decision and reducing the rewards in case of a wrong decision) could be seen as substitute tools.

6 Conclusion

In this paper, we develop a theoretical framework to investigate the impact of patent continuation on the behaviour of patent applicants and examiners. We focus on a particular continuation rule called Request for Continued Examination (RCE), which allows patent applicants to apply for continuation after their patents have received a final rejection. The rationale for this rule is to acknowledge that sometimes examiners make mistakes. By allowing patent applicants to apply for continuation, the USPTO gives them an opportunity to get their patent application re-evaluated, which should reduce type I errors (i.e., reject a patent to a patentable innovation). However, the continuation rule has an impact on the reward system of patent examiners. Indeed, examiners get less credit from evaluating continuations than from brand new applications.

We show that the existence of the continuation rule (after a final rejection) might induce patent examiners to reduce their evaluation effort and increase the granting of patents, which increases type II errors (i.e., grant a patent to a non-patentable innovation). Therefore, while trying to avoid type I errors, the USPTO does not provide adequate incentives to avoid type

II errors. In order to rectify the incentives to induce higher examination efforts, the USPTO could either 'punish' patent examiners for making type II errors or abolish the RCE rule. In other words, abolishing the RCE rule would help rectify the lack of incentives to evaluate patent applications.

This finding is in line with recommendations from Cotropia and Quillen (2018, 2019), even though they provide analyses and recommendations for all types of continuation (not just for RCE). Indeed, there are other continuation rules (continuations, continuation-in-parts, divisional applications) that allow patent applicants to add additional claims or additional subject matters to their initial inventions while their application is still under evaluation (before a final rejection). These types of continuation are often used strategically by patent applicants not only to broaden the scope of protection but also to increase the probability that subsequent technologies will infringe (Dechezleprêtre, et al., 2017; Righi and Simcoe, 2020; Righi, Cannito, Vladasel, 2023). It would thus be interesting to theoretically analyze their impact on the behaviour of patent examiners and applicants to extend the analysis to all types of continuation.

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Appendix

A.1. Bayesian updates

Using Bayes' rule, we denote $\mu_k = \Pr(\theta = 1 \mid s = k)$ where $k = \{good, bad\}$ so that

$$\mu_{good} = \Pr(\theta = 1 \mid s = good) = \frac{\Pr(\theta=1)\Pr(s=good|\theta=1)}{\Pr(\theta=1)\Pr(s=good|\theta=1)+\Pr(\theta=0)\Pr(s=good|\theta=0)},$$

where $\Pr(\theta = 1) = \mu$ and $\Pr(s = good \mid \theta = 1) = q_e$ such that

$$\mu_{good} = \frac{\mu q_e}{\mu q_e + (1-\mu)(1-q_e)}. \tag{1}$$

Similarly,

$$\mu_{bad} = \Pr(\theta = 1 \mid s = bad) = \frac{\Pr(\theta=1)\Pr(s=bad|\theta=1)}{\Pr(\theta=1)\Pr(s=bad|\theta=1)+\Pr(\theta=0)\Pr(s=bad|\theta=0)},$$

where $\Pr(s = bad \mid \theta = 1) = 1 - q_e$ such that

$$\mu_{bad} = \frac{\mu(1-q_e)}{\mu(1-q_e) + (1-\mu)q_e}. \tag{2}$$

A.2. No continuation rule

The examiner reports truthfully if $\mu_{bad} < \frac{w_0}{v_1+w_0} < \mu_{good}$, where μ_{bad} and μ_{good} are defined by (1) and (2), respectively. We show that $\mu_{bad} < w_0/(v_1 + w_0) \Leftrightarrow \mu < \overline{\mu}_{NC}(q_e)$, where

$$\overline{\mu}_{NC}(q_e) \equiv \frac{w_0 q_e}{w_0 q_e + v_1(1-q_e)},$$

and $\mu_{good} > w_0/(v_1 + w_0) \Leftrightarrow \mu > \underline{\mu}_{NC}(q_e)$, where

$$\underline{\mu}_{NC}(q_e) \equiv \frac{w_0(1-q_e)}{w_0(1-q_e) + v_1 q_e},$$

where $v_1 = s_g(1) - s_r(1) \geq 0$ and $w_0 = s_r(0) - s_g(0) > 0$. We have that $\partial\overline{\mu}_{NC}(q_e)/\partial q_e > 0$, and $\partial\underline{\mu}_{NC}(q_e)/\partial q_e < 0$, and $\underline{\mu}_{NC}(q_e) < \overline{\mu}_{NC}(q_e)$ as long as $q_e > 1/2$, which is satisfied by assumption. Thus, $\overline{\mu}_{NC}(q_1) > \overline{\mu}_{NC}(q_0) > \underline{\mu}_{NC}(q_0) > \underline{\mu}_{NC}(q_1)$.

When he gets an application, the examiner chooses to make an effort $e \in \{0, 1\}$. Conditional on reporting truthfully, his expected utility for any e is

$$\begin{aligned}
&\Pr(s = good)[\Pr(\theta = 1 \mid s = good)u(1, e, grant, nocont, d_{E/cont}) \\
&\quad + \Pr(\theta = 0 \mid s = good)u(0, e, grant, nocont, d_{E/cont})] \\
&+ \Pr(s = bad)[\Pr(\theta = 1 \mid s = bad)u(1, e, reject, nocont, d_{E/cont}) \\
&\quad + \Pr(\theta = 0 \mid s = bad)u(0, e, reject, nocont, d_{E/cont})],
\end{aligned}$$

or, equivalently,

$$\begin{aligned}
&\Pr(s = good)[\tfrac{\Pr(s=good|\theta=1)\Pr(\theta=1)}{\Pr(s=good)}u(1, e, grant, nocont, d_{E/cont}) \\
&\quad + \tfrac{\Pr(s=good|\theta=0)\Pr(\theta=0)}{\Pr(s=good)}u(0, e, grant, nocont, d_{E/cont})]) \\
&+ \Pr(s = bad)[\tfrac{\Pr(s=bad|\theta=1)\Pr(\theta=1)}{\Pr(s=bad)}u(1, e, reject, nocont, d_{E/cont}) \\
&\quad + \tfrac{\Pr(s=bad/|\theta=0)\Pr(\theta=0)}{\Pr(s=bad)}u(0, e, reject, nocont, d_{E/cont})].
\end{aligned}$$

This simplifies to

$$\begin{aligned}
&\mu q_e u(1, e, grant, nocont, d_{E/cont}) + (1-\mu)(1-q_e)u(0, e, grant, nocont, d_{E/cont}) \\
&+\mu(1-q_e)u(1, e, reject, nocont, d_{E/cont}) + (1-\mu)q_e u(0, e, reject, nocont, d_{E/cont}).
\end{aligned}$$

Once we plug the utility functions, we obtain

$$q_e(\mu(v_1 - w_0) + w_0) + (1-\mu)s_g(0) + \mu s_r(1) - c(e).$$

Thus, the examiner chooses $e = 1$ rather than $e = 0$ if

$$q_1(\mu(v_1 - w_0) + w_0) + (1-\mu)s_g(0) + \mu s_r(1) - c \geq q_0(\mu(v_1 - w_0) + w_0) + (1-\mu)s_g(0) + \mu s_r(1),$$

or, equivalently, if

$$\mu(v_1 - w_0) \geq \tfrac{c}{q_1 - q_0} - w_0.$$

There are three cases to consider: either $v_1 - w_0 > 0$, $v_1 - w_0 < 0$, or $v_1 - w_0 = 0$. First, if $v_1 > w_0$, the examiner makes a positive effort ($e = 1$) instead of no effort ($e = 0$) if $\mu > \mu_{NC}$ where

$$\mu_{NC} \equiv \tfrac{1}{v_1 - w_0}[\tfrac{c}{q_1 - q_0} - w_0], \tag{11}$$

with $0 < \mu_{NC} < 1$ if $w_0(q_1 - q_0) < c < v_1(q_1 - q_0)$. If $c \leq w_0(q_1 - q_0)$, we have $\mu_{NC} \leq 0$, and, thus, for any $\mu \in [0, 1]$ the examiner always makes a positive effort ($e = 1$). If $c \geq v_1(q_1 - q_0)$, we have $\mu_{NC} \geq 1$, and thus, for any $\mu \in [0,1]$ the examiner never makes any effort ($e = 0$). Second, we consider the case where $v_1 - w_0 < 0$. The examiner makes an effort $e = 1$ if $\mu < \mu_{NC}$ with $0 < \mu_{NC} < 1$ if $v_1(q_1 - q_0) < c < w_0(q_1 - q_0)$. If $v_1(q_1 - q_0) \geq c$, for any $\mu \in [0,1]$ the examiner makes a positive effort ($e = 1$). If $c \geq w_0(q_1 - q_0)$, for any $\mu \in [0,1]$ the examiner never makes any effort ($e = 0$). Lastly, if $v_1 = w_0$, the examiner makes a positive effort ($e = 1$) if $w_0(q_1 - q_0) > c$ for any $\mu \in [0,1]$.

To summarize, if *(i)* $v_1 > w_0$ and $c \leq w_0(q_1 - q_0)$, the examiner always chooses an effort $e = 1$ for any μ; If $c > w_0(q_1 - q_0)$, the examiner makes an effort $e = 0$ if $\mu < \mu_{NC}$ and an effort $e = 1$ if $\mu \geq \mu_{NC}$. If *(ii)* $v_1 < w_0$, and $c < v_1(q_1 - q_0) < w_0(q_1 - q_0)$, the examiner always makes an effort $e = 1$ for any μ; if $c \geq w_0(q_1 - q_0)$, the effort is $e = 1$ for $\mu < \mu_{NC}$ and $e = 0$ for $\mu \geq \mu_{NC}$. If *(iii)* $v_1 = w_0$, the examiner chooses to make a positive effort only if $v_1(q_1 - q_0) = w_0(q_1 - q_0) > c$.

At the outset, for any e, the applicant decides to apply for a patent if

$$\begin{aligned} & \mu[q_e \pi(1, e, grant, nocont, \lambda) + (1 - q_e)\pi(1, e, reject, nocont, \lambda)] \\ & +(1 - \mu)[(1 - q_e)\pi(0, e, grant, nocont, \lambda) + q_e \pi(0, e, reject, nocont, \lambda)] - C_P \\ = \; & \mu[q_e(G - \underline{G} + B) + \underline{G} - B] + (1 - q_e)B - C_P. \end{aligned}$$

Thus, as long as $\mu[q_e(G - \underline{G} + B) + \underline{G} - B] + (1 - q_e))B - C_P \geq 0$, the applicant applies for a patent, or equivalently, for any $\mu \geq \mu_P(q_e)$ with

$$\mu_P(q_e) \equiv \tfrac{C_P - (1-q_e)B}{q_e(G - \underline{G} + B) - (B - \underline{G})}.$$

We show that $\mu_P(q_0) > \mu_P(q_1)$ if $C_P > (BG)/(G - \underline{G} + B)$, which is always satisfied as $C_P > B$. We also show that $\mu_P(q_e) > \underline{\mu}_{NC}(q_e)$ whenever $\mu_P(q_e) > 0$ if $v_1 > w_0$ and $B < C_P$ (by assumption). Indeed, as $\mu_P(q_e)$ decreases, and $\mu_P(q_e = 1) = C_P/G > 0 = \underline{\mu}_{NC}(q_e = 1)$, $\mu_P(q_e) > \underline{\mu}_{NC}(q_e)$ will be true for any $q_e < 1$.

We now consider what happens when the examiner does not report truthfully. Whatever the signal received, the examiner can decide not to follow it. The examiner always grants a patent in case of a bad signal if $\mu_{bad}(s_g(1) - s_g(0)) + s_g(0) - c(e) > \mu_{bad}(s_r(1) - s_r(0)) + s_r(0) - c(e)$ or if $\mu_{bad} > w_0/(v_1 + w_0)$ or, equivalently, if $\mu > \overline{\mu}_{NC}$. The examiner who receives a good signal prefers to grant a patent if $\mu > \underline{\mu}_{NC}$. If he always grants a patent, he will make no effort as

$\mu(s_g(1) - s_g(0)) + s_g(0) - c > \mu(s_g(1) - s_g(0)) + s_g(0)$ is always satisfied. The applicant will decide to apply for a patent if $\mu G + (1 - \mu)B - C_P \geq 0$, or if $\mu \geq \mu_P$ where

$$\mu_P \equiv \tfrac{C_P - B}{G - B}.$$

Thus, for $\mu > \max\{\overline{\mu}_{NC}(q_e), \mu_P\}$, the applicant applies for a patent, the examiner makes no effort ($e = 0$) and always grants a patent.

Now consider that the examiner always rejects the patent application. He always rejects a patent after receiving a bad signal if $\mu < \overline{\mu}_{NC}$, and if he receives a good signal, he prefers to reject a patent if $\mu < \underline{\mu}_{NC}$. If he always rejects a patent, he will make no effort as $\mu(s_r(1) - s_r(0)) + s_r, (0) - c > \mu(s_r(1) - s_r(0)) + s_r(0)$ is always satisfied. The applicant will decide to apply for a patent if $\mu \underline{G} - C_P \geq 0$, which is never satisfied. Thus, for $\mu < \underline{\mu}_{NC}(q_e)$, the applicant does not apply for a patent.

A.3. Continuation rule

If inequality (15) is satisfied, the patent applicant will always continue after her patent has been rejected ($d_{A/reject} = cont$). In that case, after receiving a bad signal, the patent examiner rejects the patent if (13) is satisfied that we rewrite as follows

$$\mu_{bad} u(1, e, reject, cont, d_{E/cont}) + (1 - \mu_{bad}) u(0, e, reject, cont, d_{E/cont}) > \mu_{bad} s_g(1) + (1 - \mu_{bad}) s_g(0) - c(e),$$

or, equivalently, $\mu_{bad}(v_1^{cont} + v_0^{cont}) < v_0^{cont}$ where $v_1^{cont} = v_1 - \Phi_a$ with $\Phi_a = \lambda s_{cont,g}(1) + (1 - \lambda) s_{cont,r}(1) - s_r(1)$, and $v_0^{cont} = w_0 - \Phi_b$ with $\Phi_b = s_r(0) - (\lambda s_{cont,g}(0) + (1 - \lambda) s_{cont,r}(0)) > 0$.

We show that $v_1^{cont} > 0$, and v_1^{cont} can be larger or smaller than v_1. If we rewrite $v_1^{cont} > 0$ as $s_g(1) - (\lambda s_{cont,g}(1) + (1 - \lambda) s_{cont,r}(1)) > 0$, we have that this last inequality is always satisfied as $\lambda < (s_g(1) - s_{cont,r}(1))/(s_{cont,g}(1) - s_{cont,r}(1))$, because $(s_g(1) - s_{cont,r}(1))/(s_{cont,g}(1) - s_{cont,r}(1)) > 1$ as $s_g(1) > s_{cont,g}(1)$. As Φ_a can be positive or negative, $v_1^{cont} > v_1$ if $\Phi_a < 0$ and $v_1^{cont} < v_1$ if $\Phi_a > 0$.

Then, we show that $v_0^{cont} < w_0$ while v_0^{cont} can be positive or negative. Indeed, $v_0^{cont} = w_0 - \Phi_b < w_0$ as long as $\Phi_b = s_r(0) - (\lambda s_{cont,g}(0) + (1 - \lambda) s_{cont,r}(0)) > 0$, which is always satisfied as $s_r(0) > s_{cont,r}(0) > s_{cont,g}(0)$. Finally, we have $v_0^{cont} > 0$ if $w_0 > \Phi_b$ and $v_0^{cont} < 0$ if $w_0 < \Phi_b$.

If $v_0^{cont} < 0$, and $v_1^{cont} + v_0^{cont} > 0$ then $\mu_{bad}(v_1^{cont} + v_0^{cont}) < v_0^{cont}$ is impossible. If $v_0^{cont} < 0$, and $v_1^{cont} + v_0^{cont} < 0$ then $\mu_{bad} > v_0^{cont}/(v_1^{cont} + v_0^{cont})$. If $v_0^{cont} > 0$ (and thus $v_1^{cont} + v_0^{cont} > 0$), then

$$\mu_{bad} < \frac{v_0^{cont}}{v_1^{cont} + v_0^{cont}}.$$

Similarly, after a good signal, we can rewrite (14) as

$$\mu_{good}s_g(1)+(1-\mu_{good})s_g(0)-c(e) > \mu_{good}u(1,e,reject,cont,\lambda)+(1-\mu_{good})u(0,e,reject,cont,\lambda),$$

or, equivalently, if $v_1^{cont} + v_0^{cont} > 0$, which is also equivalent to

$$\mu_{good} > \frac{v_0^{cont}}{v_1^{cont} + v_0^{cont}}.$$

Thus, the examiner reveals truthfully the signal he received, and the applicant always continues after her patent has been rejected if (15) is satisfies and if

$$\mu_{bad} < \frac{v_0^{cont}}{v_1^{cont} + v_0^{cont}} < \mu_{good},$$

or equivalently, as long as $\underline{\mu}_C(q_e) < \mu \leq \overline{\mu}_C(q_e)$ with

$$\overline{\mu}_C(q_e) = \frac{q_e v_0^{cont}}{q_e v_0^{cont} + (1-q_e) v_1^{cont}} = \frac{q_e(w_0 - \Phi_b)}{q_e(w_0-\Phi_b)+(1-q_e)(v_1-\Phi_a)},$$

and

$$\underline{\mu}_C(q_e) = \frac{(1-q_e)v_0^{cont}}{(1-q_e)v_0^{cont} + q_e v_1^{cont}} = \frac{(1-q_e)(w_0-\Phi_b)}{(1-q_e)(w_0-\Phi_b)+q_e(v_1-\Phi_a)}.$$

We have that $\overline{\mu}_C(q_e) = 0 = \underline{\mu}_C(q_e)$ for $w_0 = \Phi_b$, and we show that $\overline{\mu}_C(q_e) > \underline{\mu}_C(q_e)$ for $w_0 > \Phi_b$, and $\partial\overline{\mu}_C(q_e)/\partial w_0 > 0$, $\partial\underline{\mu}_C(q_e)/\partial w_0 > 0$. We also show that $\partial\overline{\mu}_C(q_e)/ > \partial q_e > 0$ and $\partial\underline{\mu}_C(q_e)/\partial q_e < 0$, so that $\underline{\mu}_C(q_1) < \underline{\mu}_C(q_0) < \overline{\mu}_C(q_0) < \overline{\mu}_C(q_1)$.

In equilibrium, $\widetilde{\mu} = \mu_{bad}$ and, thus, (15) is equivalent to having $\mu > \overline{\mu}_A(q_e)$ with

$$\overline{\mu}_A(q_e) \equiv \frac{q_e(C_c - \lambda B)}{q_e(C_c-\lambda B)+(1-q_e)(\lambda(G-\underline{G})-C_c)}, \tag{25}$$

where $0 < \overline{\mu}_A(q_0) < \overline{\mu}_A(q_1) \leq 1$ as $\partial\overline{\mu}_A(q_e)/\partial q_e > 0$. We show that $0 < \overline{\mu}_A(q_0)$ and $\overline{\mu}_A(q_1) \leq 1$ are always satisfied.

When he receives an application to evaluate, the examiner must choose an effort level $e \in \{0,1\}$. Conditional on reporting truthfully as defined above, and that the applicant continues after a rejection ($d_{A|reject} = cont$) if $\mu > \overline{\mu}_A(q_e)$, the expected utility of the examiner for any e is

$$\begin{aligned} \Pr(s &= good)[\Pr(\theta = 1 \mid s = good)u(1, e, grant, d_{A/reject}, d_{E/cont}) \\ +\Pr(\theta &= 0 \mid s = good)u(0, e, grant, d_{A/reject}, d_{E/cont})] \\ +\Pr(s &= bad)[\Pr(\theta = 1 \mid s = bad)u(1, e, reject, cont, d_{E/cont}) \\ +\Pr(\theta &= 0 \mid s = bad)u(0, e, reject, cont, d_{E/cont})], \end{aligned}$$

which simplifies to

$$q_e[\mu(v_1^{cont} - v_0^{cont}) + v_0^{cont}] + (1-\mu)s_g(0) + \mu(s_g(1) - v_1^{cont}) - c(e).$$

Hence, the examiner makes effort $e = 1$ if $q_1[\mu(v_1^{cont} - v_0^{cont}) + v_0^{cont}] + (1-\mu)s_g(0) + \mu(s_g(1) - v_1^{cont}) - c > q_0[\mu(v_1^{cont} - v_0^{cont}) + v_0^{cont}] + (1-\mu)s_g(0) + \mu(s_g(1) - v_1^{cont})$ or, equivalently, if

$$\mu[v_1^{cont} - v_0^{cont}] > \frac{c}{q_1 - q_0} - v_0^{cont}.$$

If $v_1^{cont} - v_0^{cont} > 0$, we have

$$\mu > \frac{1}{v_1^{cont} - v_0^{cont}}\left(\frac{c}{q_1 - q_0} - v_0^{cont}\right) \equiv \mu_C.$$

Recall that $v_1^{cont} - v_0^{cont} = v_1 - \Phi_a - (w_0 - \Phi_b)$ and, therefore having $v_1^{cont} - v_0^{cont} > 0$ is equivalent to having $w_0 < v_1 - (\Phi_a - \Phi_b)$. If $\Phi_a - \Phi_b < 0$, it is enough to have $w_0 < v_1$ as it implies that $w_0 < v_1 - (\Phi_a - \Phi_b)$. However, when $\Phi_a - \Phi_b > 0$, we need to make sure that $w_0 < v_1 - (\Phi_a - \Phi_b) < v_1$. Having $\Phi_a - \Phi_b > 0$ is equivalent to having $\lambda(s_{cont,g}(1) - s_{cont,r}(1) - (s_{cont,r}(0) - s_{cont,g}(0))) - (s_r(0) - s_{cont,r}(0) + s_r(1) - s_{cont,r}(1)) > 0$. If $s_{cont,g}(1) - s_{cont,r}(1) - (s_{cont,r}(0) - s_{cont,g}(0)) < 0$, then $\Phi_a - \Phi_b < 0$. On the other hand, if $s_{cont,g}(1) - s_{cont,r}(1) - (s_{cont,r}(0) - s_{cont,g}(0)) > 0$, then $\Phi_a - \Phi_b > 0$ if $\lambda > \underline{\lambda}$ where

$$\lambda > \underline{\lambda} \equiv \frac{s_r(0) - s_{cont,r}(0) + s_r(1) - s_{cont,r}(1)}{s_{cont,g}(1) - s_{cont,r}(1) - (s_{cont,r}(0) - s_{cont,g}(0))}.$$

If $s_r(0) - s_{cont,g}(0) < s_{cont,g}(1) - s_r(1)$ then $\underline{\lambda} < 1$. If $s_r(0) - s_{cont,g}(0) > s_{cont,g}(1) - s_r(1)$ then $\underline{\lambda} > 1$ and thus it is impossible to have $\lambda > \underline{\lambda}$. If $s_{cont,g}(1) - s_r(1) > s_r(0) - s_{cont,g}(0)$ then $s_{cont,g}(1) - s_{cont,r}(1) > s_r(0) - s_{cont,g}(0) > s_{cont,r}(0) - s_{cont,g}(0)$, thus $s_{cont,g}(1) - s_{cont,r}(1) > s_{cont,r}(0) - s_{cont,g}(0)$. Thus, $\Phi_a - \Phi_b > 0$ if $s_{cont,g}(1) - s_r(1) > s_r(0) - s_{cont,g}(0)$ and $\lambda > \underline{\lambda}$.

At the outset, for a given level of effort e^* chosen by the examiner, the applicant decides to apply for a patent if

$$\mu[q_{e^*}\pi(1, grant, nocont, \lambda) + (1 - q_{e^*})\pi(1, reject, cont, \lambda)]$$
$$+(1 - \mu)[(1 - q_{e^*})\pi(0, grant, nocont, \lambda) + q_{e^*}\pi(0, reject, cont, \lambda)] - C_P > 0$$

where

$$\begin{aligned}\pi(1, grant, nocont, \lambda) &= G, \\ \pi(1, reject, cont, \lambda) &= \lambda G + (1 - \lambda)\underline{G} - C_c, \\ \pi(0, grant, nocont, \lambda) &= B, \\ \pi(0, reject, cont, \lambda) &= \lambda B - C_c.\end{aligned}$$

Thus,

$$\mu[q_{e^*}G - q_{e^*}(\lambda B - C_c) + (1 - q_{e^*})(\lambda G + (1 - \lambda_{e^*})\underline{G} - C_c) - (1 - q_{e^*})B] > C_P - (1 - q_{e^*})B - q_{e^*}(\lambda B - C_c),$$

or, equivalently, $\mu > \mu_{CP}(q_{e^*})$ with

$$\mu_{CP}(q_{e^*}) \equiv \frac{C_P - (1 - q_{e^*})B + q_{e^*}(C_c - \lambda B)}{q_{e^*}(C_c - \lambda B + G) + (1 - q_{e^*})(\lambda(G - \underline{G}) - B + \underline{G} - C_c)}.$$

We show that $\mu_{CP}(q_0) > \mu_{CP}(q_1)$. Let's denote $\mu_{CP}(q_0) = N_{q_0}/D_{q_0}$ and $\mu_{CP}(q_1) = N_{q_1}/D_{q_1}$.

We show that $N_{q_0}D_{q_1} > N_{q_1}D_{q_0}$ if $B\,(G - \underline{G})\,\lambda^2 - (B(C_P + C_c - \underline{G}) + (C_P + C_c)\,(G - \underline{G}))\,\lambda + (C_P(B - \underline{G}) + G(C_P - B) + C_c(2C_P + C_c - \underline{G})) > 0$, which is always satisfied for $\lambda \in (0, 1)$.

Finally, we show that $\mu_{CP}(q_e) < \overline{\mu}_A(q_e)$ for any q_e if C_P is small enough. Let denote $\overline{\mu}_A = N_A/D_A$ with $N_A = q_e(C_c - \lambda B)$ and $D_A = q_e(C_c - \lambda B) + (1 - q_e)(\lambda(G - \underline{G}) - C_c)$. Thus, $\mu_{CP} = (N_A + C_P - (1 - q_e)B)/(D_A + q_eG - (1 - q_e)(B - \underline{G}))$. We show that $\overline{\mu}_A > \mu_{CP}$ if $(C_P - (1 - q_e)B)D_A < N_A(q_eG - (1 - q_e)(B - \underline{G}))$ or if $C_P < (1 - q_e)B + N_A(q_eG - (1 - q_e)(B - \underline{G}))/D_A$.

A.4. Comparison of continuation and no continuation rules

We first show that $\mu_C > \mu_{NC}$ when $c < v_1(q_1 - q_0)$. Recall that

$$\mu_{NC} = \frac{1}{v_1 - w_0}[\frac{c}{q_1 - q_0} - w_0],$$

and

$$\mu_C = \frac{1}{v_1^{cont} - v_0^{cont}}[\frac{c}{q_1 - q_0} - v_0^{cont}] = \frac{1}{v_1 - w_0 - (\Phi_a - \Phi_b)}[\frac{c}{q_1 - q_0} - w_0 + \Phi_b].$$

Thus, $\mu_C > \mu_{NC}$ is equivalent to having $\Phi_a(\frac{c}{q_1-q_0} - w_0) + \Phi_b(v_1 - \frac{c}{q_1-q_0}) > 0$, which is always satisfied for $v_1 > \frac{c}{q_1-q_0}$ and $\frac{c}{q_1-q_0} > w_0$. We further calculate the following derivatives $\partial\mu_{NC}/ < 0$, $\partial\mu_C/\partial w_0 < 0$, $\partial^2\mu_{NC}/\partial w_0^2 < 0$ and $\partial^2\mu_C/\partial w_0^2 < 0$. Evaluated at $w_0 = 0$, we have

$$\mu_{NC}(w_0 = 0) = \frac{1}{v_1}\frac{c}{q_1 - q_0},$$

and

$$\mu_C(w_0 = 0) = \frac{1}{v_1 - \Phi_a + \Phi_b}[\frac{c}{q_1 - q_0} + \Phi_b],$$

where $v_1 - (\Phi_a - \Phi_b) > 0$. We check that $\mu_{NC}(0) < \mu_C(0)$ as long as $\frac{c}{q_1-q_0}\Phi_a + \Phi_b(v_1 - \frac{c}{q_1-q_0}) > 0$, which is always satisfied for $v_1(q_1 - q_0) > c$. Furthermore, $\mu_{NC} = 0$ for $w_0 = c/(q_1 - q_0)$ and $\mu_C = 0$ for $w_0 = c/(q_1 - q_0) + \Phi_b$, where $c/(q_1 - q_0) < c/(q_1 - q_0) + \Phi_b$. Thus, we have that $\mu_{NC} < \mu_C$ for any $w_0 < v_1$.

We now show that $\overline{\mu}_{NC}(q_e) \geq \overline{\mu}_C(q_e)$ and $\underline{\mu}_{NC}(q_e) \geq \underline{\mu}_C(q_e)$ for any q_e if $v_1^{cont} w_0 \geq v_1 v_0^{cont}$ or, equivalently, if $w_0 \leq \frac{\Phi_b}{\Phi_a} v_1$. In fact, we have that $\overline{\mu}_{NC}(q_e) = \overline{\mu}_C(q_e)$ and $\underline{\mu}_C(q_e) = \underline{\mu}_{NC}(q_e)$ for $w_0 = \frac{\Phi_b}{\Phi_a} v_1$. If $\Phi_a > \Phi_b$, then $w_0 = \frac{\Phi_b}{\Phi_a} v_1 < v_1$, whereas if $\Phi_a < \Phi_b$, then $w_0 = \frac{\Phi_b}{\Phi_a} v_1 > v_1$.