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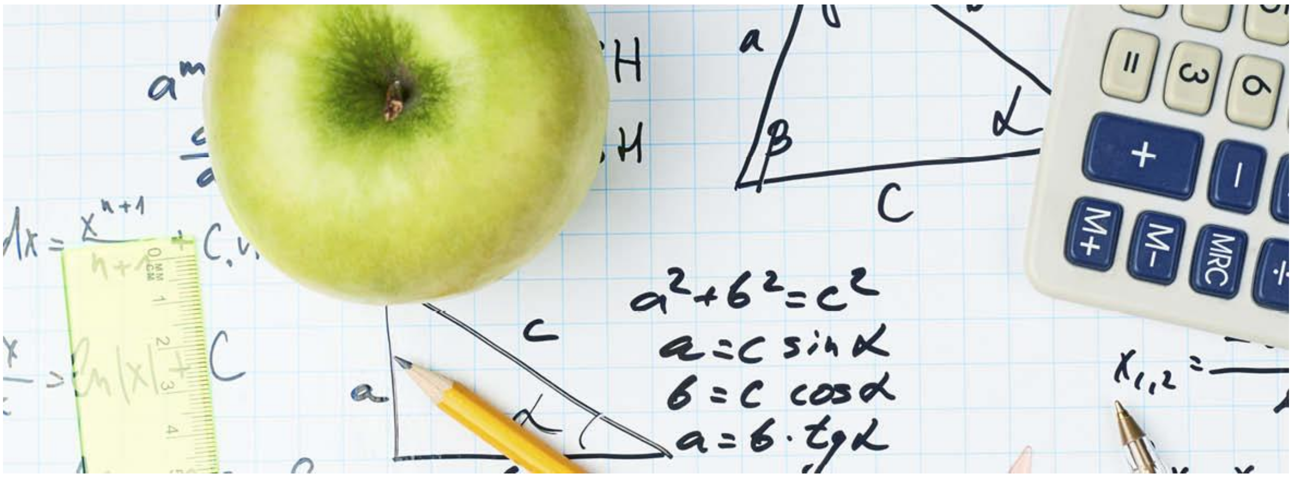

Physician Response to Target-Based Performance Payment

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Abstract

In many health care systems payers reward physicians for reaching predetermined performance targets. These targets may be based on measures for which own performance is difficult to predict. This paper uses a principal-agent model to analyse physicians' response to a target-based performance payment and the role uncertainty about own performance plays. It is shown that physicians' response depends on their type (determined by abilities and preferences), the size of the performance payment, and their uncertainty about own performance. Only in the presence of uncertainty do all physician types respond to the target payment, and they respond by increasing effort. Meanwhile, increased uncertainty leads some physician types to reduce the magnitude of their response and other types to increase their response. Therefore, when designing target-based payment schemes it is important to perform baseline measurements to assess the distribution of physician types and to predict physicians' ability to assess own performance.

Key Words: Health Care, Pay for performance, Target-based payment, Uncertainty

JEL Codes: C91, I11

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1 Introduction

One of the main objectives for a health care payer is to ensure that their physicians deliver high-quality care, which means delivering care that benefits patients' treatment process or health outcome (Chalkley and Malcomson, 1998). To reach this goal an increasing number of health care systems have adopted pay for performance (P4P) schemes (Cashin et al., 2014). In these schemes physicians are paid for their performance on indicators which are considered proxies for the quality of health care. The payment for performance is often made nonlinear such that payment is only given for reaching a predetermined target level (Rosenthal et al., 2005; Rosenthal and Dudley, 2007; Cashin et al., 2014).

Performance targets are popular as they send a clear signal to physicians about the expected quality of care (Degeorge et al., 1999; Cromwell et al., 2011). However, under these schemes some physicians are found to fall behind and some to surpass the target (Doran et al., 2010). One explanation for this finding could be that physicians' performance may not solely depend on their own effort, but may also depend on exogenous factors such as patient compliance; moreover it may be measured with error. Consequently, physicians may be uncertain about the relationship between the effort they exert and the performance they achieve. The purpose of this paper is to investigate how physicians respond to a target-based P4P-scheme and the role uncertainty plays, and thereby to provide guidance to those designing these schemes.

The popularity of target-based payment schemes stands in contrast to the literature stating the incentive problems of nonlinear performance contracts (Healy, 1985; Holmstrom and Milgrom, 1987). Critics argue that performance payments which fail to offer a financial reward for performance falling short of a target may discourage physicians, who find it difficult to reach the lower bound. Whereas payment schemes not rewarding performance beyond some upper limit leaves no incentive to increase effort even further (Rosenthal et al., 2005; Giuffrida et al., 1999). It has also been shown that threshold-based payment schemes may cause physicians to game in the neighbourhood of thresholds (Gravelle et al., 2010).

The literature, however, also describes beneficial aspects of using target-based payment schemes. These advantages are present when a provider is uncertain about own performance. Zhou and Swan (2003) show that under certain conditions, it is optimal for the payer to use contracts with no performance payment below a threshold compared to a contract which rewards proportional to performance, because the threshold mitigates agency costs associated with the downside risk of production. Arnaiz and Salas-Fumas (2008) provide sufficient conditions under which the second-best contract can resemble a contract that sets a lower and upper bound on performance payments. The intuition behind their result is that extreme values of the performance variable are uninformative about the agent's actions.

The existing literature on target-based P4P schemes and provider uncertainty disregard an important issue, which applies in health care; namely that physicians differ in abilities and preferences, and because this information is private, payers are forced to offer the same contract to all agents. Even if physicians' types are revealed, unions may impose uniform contracts. Health care payers therefore often set the same performance level requirements across all physicians (Roland, 2004; Rosenthal et al., 2004). This paper contributes to the literature by considering how different types of physicians respond to the same target-based P4P contract; more specifically the role uncertainty plays for their behaviour.

Physicians are characterised by being benevolent in the sense that they are intrinsically concerned about the quality of health care provided to their patients, i.e. they may choose to deliver high-quality care without P4P (Godager and Wiesen, 2013). The physician thus acts as an agent to both the patient and the payer. Following the tradition of the literature on physician decision-making (see for example McGuire and Pauly (1991); Chalkley and Malcomson (1998); Makris and Siciliani (2013)), I use a principal-agent framework to explain the behaviour of the utility maximising physician given the contract provided by the health care payer. To link the setting closer to the real world, it is assumed that the physicians are self-employed general practitioners (GPs) remunerated based on P4P (as is the case in for example the UK and the US (Cashin et al., 2014)).

First, I develop a benchmark for the analysis of P4P by examining GP's choice of effort when facing a fixed-salary payment scheme. Next, I study the GP's response to P4P distinguishing between two cases: (1) where the GP is able to perfectly predict performance; and (2) where the GP is uncertain about the effort-performance relationship. I show that the GP's response to the introduction of P4P depends on his or her type, which is determined by inherent ability and preferences for leisure and quality health care. In case (1) I predict that some types of GPs increase their effort from below the target to the exact target level in response to P4P. In case (2) given uncertainty I find that all types of GPs increase their effort in response to P4P. Thus, I conclude that more types of GPs increase their effort when they cannot perfectly predict their performance.

Although uncertainty about the effort-performance relationship causes more types of GPs to increase their effort, I find that the total amount of effort exerted by all GPs can either increase or decrease. The reason is that uncertainty makes it less attractive for some types of GPs to exert effort in an attempt to reach the performance target. The effect of uncertainty on the total amount of effort exerted by the GPs thus depends on the distribution of types, the size of the performance payment, and the degree of uncertainty.

From the results I conclude that two important steps must be taken when designing a target-based P4P scheme: First, the initial distribution of physicians' performance must be determined (baseline measurement), and thereby an identification of physicians that the payer primarily wishes to incentivise. Second, the interplay between the placement of the performance target, the size of the performance payment, and the allowed degree of uncertainty about the effort-performance relationship needs to be considered. Thus, physicians' uncertainty about own performance may be used as an instrument to affect their behaviour. In some cases it may thus be preferable for payers to choose a performance indicator with a relatively large degree of uncertainty for physicians (e.g. an outcome indicator), and in other cases it may be better to choose a more easierly controllable indicator (e.g. a process indicator).

The remainder of this paper is organised as follows. Section 2 introduces the theoretical framework. Section 3 derives the GP's optimal choice of effort under P4P. Section 4 introduces uncertainty about the GP's effort-performance relationship. Section 5 concludes the paper.

2 The model

General practitioners are considered medical generalists as they are responsible for treating patients' ordinary medical conditions, providing health care counselling, and assessing the need for specialised treatment. They are often self-employed[1] supplying own labour into the production of health care such that they take into account both net revenue and own leisure (Scott, 2000). I assume that GP's utility, u_i, depends on net revenue, own leisure, and also the quality of health care provided[2],

$$u_i(e_i) = \gamma_i h(\alpha_i e_i) + r - c_i(e_i) \tag{1}$$

where γ_i is valuation of quality health care, h is quality of health care provided to patients depending on GP's exerted effort e_i and inherent ability α_i, r is revenue, c_i is both monetary and non-monetary costs (loss of leisure) of producing quality health care.

The literature on medical decision-making has acknowledged that physicians exert altruistic behaviour (see for example Ellis and McGuire (1986); Chalkley and Malcomson (1998); Eggleston (2005); Makris and Siciliani (2013)) and recent empirical evidence supports this assumption (Godager and Wiesen, 2013). I therefore assume that GPs derive utility from improving the quality of provided care, and that this utility depends on both their degree of altruism and valuation of their reputation amongst colleagues and patients, which is reflected by $\gamma_i > 0$.

General practitioner's effort $e_i > 0$ relates to resources spent on treating patients (both contractual and non-contractual). Effort and quality of health care are often considered strongly positively correlated, causing the terms "effort" and "quality" to be used interchangeably.[3] In this model a positive correlation is therefore assumed. In addition, quality of health care is assumed twice differentiable in effort, where $h(e_i) > 0$,$h'(e_i) > 0$,$h''(e_i) < 0$, implying that the first unit of effort is the most effective. I assume that GPs differ in their inherent ability $\alpha_i > 0$ to provide quality care and that his ability acts as an amplifier of effort, i.e. $\alpha_i e_i$ determines the quality of health care delivered.

Providing effort - and thereby increasing quality of health care - is costly. Thus, the GP experiences a utility loss of c_i from exerting effort. The costs can be divided into monetary and non-monetary costs of exerting effort. The monetary costs arise from paying for equipment and

[1]GPs are self-employed in countries such as the US, Denmark, Norway, Italy, and predominately the UK (Thomson et al., 2012).

[2]For simplification all arguments in the utility function are additively separable.

[3]I recognise that in the literature this positive correlation does not always exists (see e.g. Tancredi and Barondess (1978).

human resources put into the production of care. One may argue that increased effort reduces the total monetary costs of treatment as it may lead to fewer complications from treatment (Hvenegaard et al., 2011). As GPs have the option to refer patients and thereby avoid increased long-term costs going along with low-quality care, I assume a positive linear relationship between monetary costs and effort.

The non-monetary costs arise from loss of leisure, which is assumed to increase at the margin when exerting more effort, such that $c_i(e_i) > 0$, $c_i'(e_i) > 0$, and $c_i''(e_i) > 0$. This assumption captures the fact that the GP is subjected to a time constraint; hence, as effort increases the GP has less time for non-work related activities. As preferences may differ, the utility from leisure is assumed not necessarily the same across GPs and thus the cost function may differ.

General practitioners' revenue, r, depends on the contract with the payer. This contract varies significantly between health care systems (Thomson et al., 2012). In the following the baseline for our analysis is a fixed salary payment. Given this contract, I analyse GPs' response to the introduction of target-based performance payment.

3 GPs' response to a target-based P4P

I start by considering GP's decision-making in the benchmark case where GP revenue solely consists of a fixed salary, S, which is independent of effort. The GP's utility maximisation problem thus reads,

$$\max_{e_i} u_i(e_i) = \gamma_i h(\alpha_i e_i) + S - c_i(e_i) \tag{2}$$

The effort, e_i^s, which maximises GP utility under the fixed salary scheme is implicitly given by,

$$\gamma_i \alpha_i h'(\alpha_i e_i^s) = c_i'(e_i^s) \tag{3}$$

Effort is supplied until its marginal gain equals marginal costs from improving patients' health care. Optimal effort is thus independent of salary, which therefore cannot serve as an instrument for influencing GP behaviour. The optimal level of effort, e_i^s, may differ between GPs because they differ in their ability to provide quality health care, α_i, their preferences for providing quality health care, γ_i, and for leisure, c_i. The higher inherent ability, the higher the (marginal) value of delivering quality health care, and the lower the (marginal) value of leisure, the more effort is predicted.

One of the main goals for a health care payer is to get GPs to deliver high-quality health care. As a fixed salary cannot be used to affect GPs' behaviour, payers often look to alternative payment methods. A possible way to improve quality of care is to reward GPs for their effort. However, effort is only observable for GP themselves. Hence, the health care payer cannot reward GP's effort directly but instead must use an observable performance measure which is expected to be positively correlated with effort. In this section I analyse the effect of paying for reaching a performance target on an observable performance indicator. Pay for Performance schemes typically include more than one performance indicator. To simplify, a single indicator scheme is considered here which is positively correlated with effort and also with the quality of health care provided.[4] The target performance level may be interpreted as the payer's assessment of the limit for high-quality care.

In this section I assume that GPs are able to perfectly predict performance on the indicator, i.e. they are certain about their revenue at any effort level they choose to provide. Certainty about the effort-performance relationship is a restrictive assumption. Still, it may approximately hold for GPs who have experience with the scheme and when performance is measured using process indicators that are closely linked to GP effort. The GP's utility maximisation problem becomes,

$$\max_{e_i} u_i\left(e_i\right) = \gamma_i h\left(\alpha_i e_i\right) + \rho\theta\left(\alpha_i e_i\right) - c_i\left(e_i\right) \tag{4}$$

Payment for performance is measured by $\rho\theta$, where ρ is the payment if the performance target is met and θ is a binary performance measure, which equals one if the target is met $(\alpha_i e_i \geq \nu)$ and zero otherwise $(\alpha_i e_i < \nu)$, where $\frac{\nu}{\alpha_i}$ is the minimum effort required to reach the target given ability α_i. Thus, the GP does not receive any P4P if s(he) performs below the set target and if s(he) meets the performance target s(he) receives the payment, ρ, which is independent of any further improvement of performance. GP's performance is solely determined by ability and effort, i.e. $\alpha_i e_i$, thus the higher inherent ability the GP has, the less effort is required to reach a given performance level. The performance payment at the target, ρ, can both be considered monetary and non-monetary, because it may be professionally satisfying to reach the target the health care payer has set as the limit for "high-quality care".

The solution to the GP's maximisation problem is not straightforward as it depends on the binary performance measure, $\theta\left(e_i\right)$, which is non-differentiable at the target. The effect the target payment has on the GP's optimal choice is therefore analysed by considering different types of GPs' response to P4P. The GPs are divided into two types, who differ in their choice of effort in a fixed salary regime: A type 1 GP chooses to exert effort below the target level in a fixed salary regime, i.e. $\alpha_i e_i^s < \nu$. A type 2 GP on the other hand exerts effort at or above the target level, i.e. $\alpha_i e_i^s \geq \nu$, when only remunerated a fixed salary. The difference between the two types of GPs' performances is driven by their inherent abilities and preferences for leisure and supply of quality health care.

First consider how the target payment affects the type 1 GP's optimal choice of effort, e^p. The prospect of receiving a performance payment may incentivise a type 1 GP to increase his or her effort to the target level, i.e. "jump" to the target. The GP will jump when the performance payment combined with the gain from improving the quality of patients' health care compensates him for the increased costs of effort at the target level,

[4] I therefore disregard potential issues associated with multitasking (Eggleston, 2005).

$$\rho + \gamma_i h(\nu) - \gamma_i h(\alpha_i e_i^s) \geq c_i\left(\frac{\nu}{\alpha_i}\right) - c_i(e_i^s), \ for\ \alpha_i e_i^s < \nu \tag{5}$$

The type 1 GP for which Equation 5 holds thus chooses to exert effort such that $e_i^p = \frac{\nu}{\alpha_i}$, i.e. at the exact target level. If Equation 5 does not hold, then the type 1 GP chooses not to alter his or her effort when introduced to the P4P. In this case his or her choice of effort is the same as in a setting with a remuneration scheme solely consisting of a fixed salary, i.e. $e_i^p = e_i^s$, corresponding to an effort level determined solely by Equation 3.

Now turning to a type 2 GP's response to the target. This type of GP chooses not to alter his or her effort as a response to the P4P. This result is because a GP, who under a fixed salary scheme exerts effort at or above the target level, i.e. $\alpha_i e_i^s \geq \nu$, does not receive a reward for increasing his or her effort further. Hence, this GP merely considers the P4P as an increase in his or her salary, S, which cannot be used as an instrument to affect effort, thus the solution in Equation 3 still holds under P4P such that $e_i^p = e_i^s$.

Observation 1 articulates the GP's choice of effort when paid for reaching a target-based performance level compared to being paid solely a fixed salary,

Observation 1. *A general practitioner who is certain about his or her own performance only responds to a target-based performance payment if s(he) exerts effort below target when only paid a fixed salary and the performance payment exceeds his or her net cost of increasing effort to the target level. In which case the general practitioner responds by increasing effort such that s(he) exactly reaches the target.*

The results from this section, where GPs can perfectly predict their performance, implies that health care payers can only use P4P as an instrument to affect GPs' behaviour if they otherwise perform below target, and the P4P is large enough to cover the increased costs of effort.

4 The role of uncertainty in GPs' response to a target-based P4P

The previous section assumes that the GP is able to predict his or her performance perfectly. This assumption does not reflect the reality the GP often faces. Uncertainty may for example be high if performance is measured based on patient reliant outcomes or it is costly to monitor own performance or if the GP has no previous knowledge about own performance for a given indicator. The GP's uncertainty may influence the effort that s(he) is willing to exert when remunerated for his or her performance, because s(he) may be unable to predict his or her payment for a given effort level.

The GP's uncertainty is modelled as a potential shock to his or her performance, which occurs after s(he) has exerted effort. The shock does therefore not affect the GP's costs or altruistic and reputational gain from exerting effort only whether s(he) receives a performance payment or not. The GP's potential shock to performance is denoted ε, and thus affects the performance measure, $\theta\left(\alpha_i e_i + \varepsilon\right)$, which equals one if the GP reaches the performance target and zero otherwise. The term ε is assumed to be a stochastic shock unobserved by the GP and normally distributed with mean zero, $\varepsilon \sim N\left(0, \sigma^2\right)$. The normal distribution has previously been used in the literature to describe uncertainty about performance (Eggleston, 2005). The characteristics of the shock means that the GP expects on average to predict his or her performance correctly and it is unlikely that s(he) experiences a large shock to performance. Furthermore, the shock is assumed independent of the GP's behaviour, i.e. the effort s(he) exerts and his or her inherent ability to provide quality health care.

4.1 GPs' response to P4P in the presence of uncertainty

Under uncertainty the GP thus faces the expected payment for performance $\rho E\theta\left(\alpha_i e_i + \varepsilon\right) = \rho p\left(\alpha_i e_i, \sigma^2\right)$, where the function p denotes the probability of the GP reaching the target, i.e. receiving the payment for performance. This probability depends on the effort the GP exerts, e_i, his or her inherent ability to provide quality care, α_i, and the variance of the random shock to performance, σ^2. The GP's utility maximisation problem is thus given as,

$$\max_{e_i} Eu_i\left(e_i\right) = \gamma_i h\left(\alpha_i e_i\right) + \rho p\left(\alpha_i e_i, \sigma^2\right) - c_i\left(e_i\right) \tag{6}$$

As the shock to performance is assumed normally distributed the expected payout from P4P is a continuous function of effort. The GP's optimal choice of effort under uncertainty, e_i^u, is thereby given as,

$$\gamma_i \alpha_i h_e'\left(\alpha_i e_i^u\right) + \rho \alpha_i p_e'\left(\alpha_i e_i^u, \sigma^2\right) = c_i'\left(e_i^u\right) \tag{7}$$

The more effort s(he) exerts the higher is the probability of reaching the target, i.e. $\alpha_i p_e'\left(\alpha_i e_i\right) > 0$. The GP should thus exert effort until his or her marginal gain from increasing the probability of receiving P4P with the marginal gain from improving the quality of patients' health care together equals the marginal costs of effort. Thus, when the GP is uncertain about the effort-performance relationship the introduction of P4P leads to an increase in gain from exerting effort of $\rho \alpha_i p_e'\left(\alpha_i e_i^u, \sigma^2\right)$. Observation 2 articulates the uncertain GP's choice of effort when paid for reaching a target performance compared to being paid a fixed salary,

Observation 2. *A general practitioner who is uncertain about own performance responds to the introduction of a target-based performance payment by increasing effort.*

This observation differs from the findings in Section 3, where the GP is assumed to be certain about the effort-performance relationship when offered a target-based performance payment. Recall when GPs are certain about their performance only a GP, who otherwise exerts effort below the target level, may potentially increase his or her effort when introduced to P4P. Thus, the types of GPs, who respond to P4P, is sensitive to whether GPs are certain about their performance or not. This finding is articulated in the following proposition,

Proposition 1. *When there is uncertainty about own performance more types of general practitioners increase effort as a response to a target-based performance payment than under certainty.*

It has now been shown that more types of GPs increase their effort as a response to P4P, when GPs are uncertain about their performance. Does this finding mean that GPs' uncertainty is preferred from the health care payer's point of view? The answer depends on the payer's utility function, i.e. whether for example the payer aims to increase merely the amount of GPs reaching the performance target ("limit for high-quality health care") or the total amount of quality health care supplied. Therefore two standings are considered in the following subsections: The types of GPs initially exerting effort below the target who choose to exert effort at or above the target level as a response to uncertainty and the effect of uncertainty on the total level of effort exerted by all GPs.

4.2 GPs' choice to exert the target effort level in the presence of uncertainty

To investigate how uncertainty about the effort-performance relationship affects the GP's incentive to exert effort at the target level two different types of GPs are considered: a type 1 and a type 2 GP. Recall from Section 3 that the two types are defined by whether the GP chooses to exert effort at or above the target level in a fixed salary regime and this choice is driven by differences in preferences and inherent abilities. First, consider the type 1 GP, who is characterised by exerting effort below the target level in a fixed salary regime, i.e. $\alpha_i e_i^s < \nu$. This type of GP only chooses to respond to P4P by exerting effort at the target level, if the P4P gain combined with the improvement of patients' health care compensates him for the increased costs of effort at the target level. A type 1 GP's expected utility at the target can therefore be used to compare the amount of type 1 GPs, who choose to exert the target effort level under certainty and uncertainty, respectively.

As uncertainty only affects the expected performance payment, the only difference between the type 1 GP's expected utility in the two states of certainty is this payment. When the GP is certain about the effort-performance relationship, the expected P4P at the target is ρ, and when s(he) is uncertain it becomes $\rho\, p\left(\alpha_i e_i, \sigma^2\right)$. As $\rho p\left(\alpha_i e_i, \sigma^2\right) < \rho$ it is not as profitable for a type 1 GP to exert effort at the target level, when s(he) is uncertain about own performance. The more uncertain s(he) is about own performance, the less profitable s(he) finds it to exert effort at the target level. Thus, fewer kinds of type 1 GPs choose to exert effort at the target level when they are uncertain about the effort-performance relationship.

Now, consider the type 2 GP. This GP is characterised by exerting effort at or above the target level when merely receiving a fixed salary, i.e. $\alpha_i e_i^s \geq \nu$. Section 3 found that when a type 2 GP is certain about own performance s(he) does not alter his or her effort when introduced to P4P. This result is because the performance payment does not increase as effort is increased above the target level. On the other hand if the type 2 GP is uncertain about own performance, s(he) now chooses to respond to a performance payment by increasing effort, because his or her gain from exerting effort increases with $\rho \alpha_i p_e' \left(\alpha_i e_i^s\right) > 0$, as stated in Observation 2. Thus, type 2 GPs choose effort above target level also under uncertainty.

These findings about the type 1 and type 2 GP effort level leads to the following proposition,

Proposition 2. *When general practitioners are uncertain about own performance, the introduction of a target-based performance payment causes fewer types of general practitioners to exert effort at or above the target level compared to a situation of certainty. The more uncertain general practitioners are about own performance, the fewer types choose to exert effort at or above the target level.*

4.3 GPs' choice of amount of effort in the presence of uncertainty

As previously stated, the health care payer's interest may also be in maximising the amount of quality health care provided, which not only relies on the amount of GPs below the target who choose to reach the target effort level but also on the amount of effort exerted both above and below the target. Hence, it is now investigated how uncertainty about performance affects the amount of effort exerted. To investigate the effect of uncertainty on total effort the results so far are considered. Proposition 1 states that more types of GPs increase their effort when they are uncertain about own performance than under certainty. In contrast Proposition 2 states that fewer types of GPs exert enough effort to reach the target performance level when there is uncertainty. These findings raise the question of which effect dominates the total amount of effort exerted?

4.3.1 Amount of effort and type

Inherent abilities and preferences for providing quality health care and spare time are assumed to differ across GPs. First, consider how the GP's type influences his or her effort when introduced to a payment target under certain performance. As shown in Section 3 only GPs, who in a fixed salary regime exert effort below the target (type 1), may choose to increase effort as a response to P4P. The closer the type 1 GP exerts effort to the target level under a fixed salary regime, the more likely it is that s(he) finds it profitable to increase effort when introduced to P4P. This finding means that the more type 1 GPs, who perform close enough to the target to find it profitable to reach the target, the more effort is exerted as a response to P4P.

In Section 3 it was also found that the type 1 GP never finds it profitable to exert effort above the target, when s(he) is certain about his or her performance. Thus, the closer to the target a type 1 GP responding to the payment initially performs, the less s(he) increases his or her effort. The total increase in effort as a response to P4P, when there is certainty about performance, thereby depends both on the amount of type 1 GPs finding it profitable to exert effort at the target level and on these GPs' initial effort's closeness to the target.

Now consider a situation where GPs are uncertain about the effort-performance relationship. As stated in Proposition 1, in this case all types of GPs increase effort when introduced to P4P. Figure 1 illustrates the GP's monetary gain from increasing effort when introduced to a target performance measure, i.e. $\rho\alpha_i p'_e\left(\alpha_i e_i, \sigma^2\right) > 0$. The figure depicts the gain from increasing effort in the case of the GP initially (i.e. in a fixed salary regime) exerting "low effort" and the case of him initially exerting "high effort" on both sides of the target. As seen from the figure, the closer to the target the GP exerts effort, the more s(he) alters his or her probability of crossing the target when increasing effort, i.e. $\frac{\partial^2 p\left(\alpha_i e_i, \sigma^2\right)}{\partial^2 e_i} > 0$ for $\alpha_i e_i < \nu$ and $\frac{\partial^2 p\left(\alpha_i e_i, \sigma^2\right)}{\partial^2 e_i} < 0$ for $\alpha_i e_i > \nu$, see Appendix A for a formal proof. This result can be explained by the fact that the closer to the target the GP exerts effort, the higher is the probability of a shock altering his or her performance.

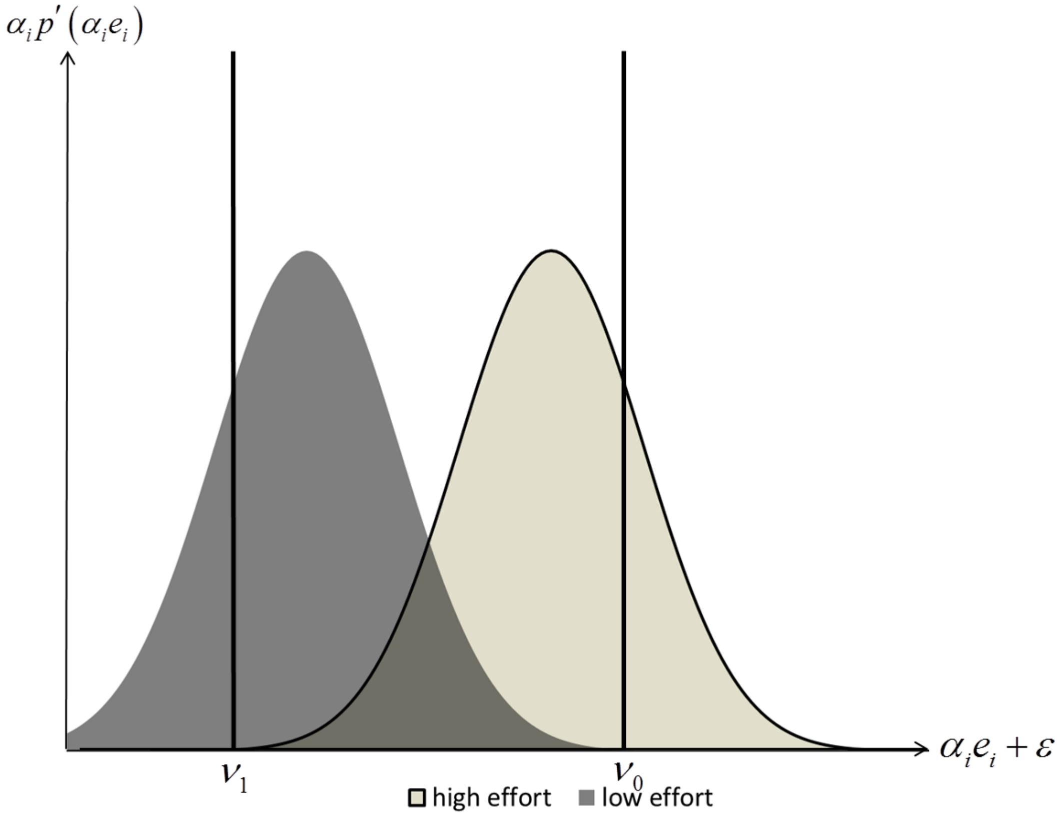
These findings about a GP's type and P4P leads to the following proposition,

Proposition 3. *A general practitioner's type affects the size of his or her response to the introduction of a target-based P4P. The sign of the effect depends on whether the general practitioner is certain about own performance. If the general practitioner is certain about own performance and responds to the performance payment, then the closer to the target s(he) initially exerts effort, the less s(he) increases effort. Conversely, if the general practitioner is uncertain about the effort-performance relationship, then the closer to the target the general practitioner initially exerts effort, the more s(he) increases effort as a response to the payment.*

4.3.2 Amount of effort and degree of uncertainty

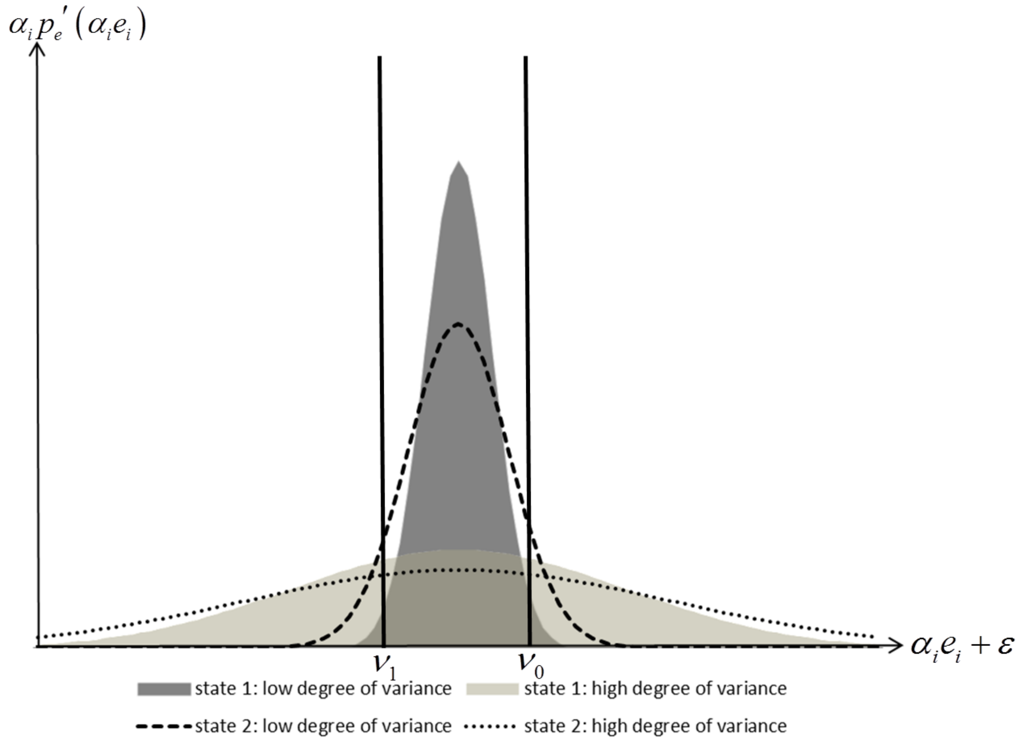
Now turn to investigate how the GP's degree of uncertainty about the effort-performance relationship affects the amount of effort s(he) exerts when introduced to a target-based performance payment. Figure 2 illustrates how the degree of uncertainty at a chosen effort level affects the GP's expected monetary gain from increasing effort. In the figure, two states of uncertainty is depicted for a given effort level, where uncertainty in state 1 is marginally lower than in state 2, i.e. $\sigma_1^2 < \sigma_2^2$. As seen from the figure, the effect of a change from state 1 to state 2 on a GP's gain from exerting effort depends on his or her initial degree of uncertainty in state 1 (high or low). When the degree of uncertainty is high, the graph for state 1 is above the graph for state 2 at the target effort level. This finding shows that the more uncertain the GP is about own performance, the more likely it is that a marginal increase in uncertainty decreases his or her expected utility gain from increasing effort, i.e. $\frac{\partial^2 Eu_i}{\partial e_i \partial \sigma^2} < 0$. Whereas when the degree of uncertainty is low, the graph for state 2 is above the graph for state 1 at the target level. Thus, the more certain the GP is about own performance, the more likely it is that a marginal increase in uncertainty increases the GP's expected utility gain from increasing effort, i.e. $\frac{\partial^2 Eu_i}{\partial e_i \partial \sigma^2} > 0$.

Figure 1: Effect of increasing effort on the probability of reaching the target at different effort levels



Notes: The target ν_0 is the case where the GP exerts effort below target. The target ν_1 is the case where the GP exerts effort above target.

Figure 2: Effect of increasing effort on the probability of reaching the target as uncertainty increases from different degrees



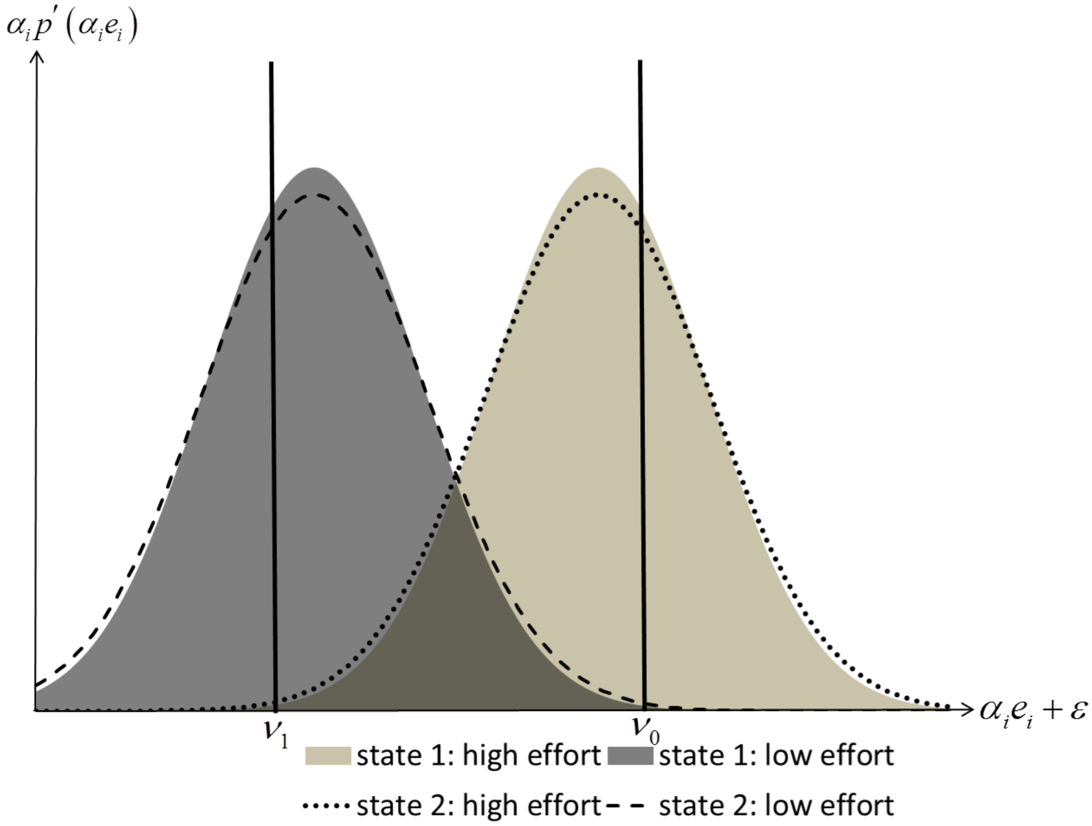
Notes: The target ν_0 is the case where the GP exerts effort below target. The target ν_1 is the case where the GP exerts effort above target. In state 1 the variance of the potential shock to performance is σ_1^2, which is marginally lower than the variance of a potential shock in state 2, σ_2^2, i.e. $\sigma_1^2 < \sigma_2^2$

The findings may be explained by the fact that if the GP is highly uncertain about own performance, then the likelihood of the performance payment being altered is already high, thus an increase in effort has likely not a large effect on the expected payout. Whereas if his or her uncertainty about performance is low, the GP may find it more profitable to increase effort if uncertainty increases marginally, because s(he) still to a high degree can affect his or her probability of receiving the performance payment, all else equal.

In Proposition 3 it is stated that the GP's effort's distance to the target level affects his or her response to a target performance payment. In figure 2 it is shown that the GP's degree of uncertainty also affects his or her response to the payment. There is a link between the GP's effort's distance from target and his or her degree of uncertainty because the further away from the target the GP exerts effort, the more certain s(he) is about own performance. This link means that his or her effort's distance from the target level affects the impact uncertainty has on the GP's gain from exerting effort.

Figure 3 shows how the effort's distance from the target level affects the impact uncertainty has on the gain from exerting effort. In the figure two states of uncertainty are depicted ($\sigma_1^2 < \sigma_2^2$) for the two cases: the GP exerting high or low effort. In the case of the GP exerting a low level of effort below the target, the effort gain from state 2 is higher than in state 1, thus an increase in the variance increases the GP's gain from exerting effort. The same applies above the target when the GP exerts a high level of effort. This finding can be explained by the fact that when the GP exerts effort far away from the target, only a large degree of uncertainty may give him a reasonable probability of altering his or her performance payment, and thus the incentive to exert effort increases as uncertainty rises, $\frac{\partial^2 Eu_i}{\partial e_i \partial \sigma^2} > 0$. Conversely, the closer the GP exerts effort to the target, the more uncertain s(he) is about whether s(he) receives the payment or not. Thus, the more likely it is that an increase in uncertainty about performance decreases his or her expected utility gain from exerting effort, i.e. $\frac{\partial^2 Eu_i}{\partial e_i \partial \sigma^2} < 0$. This finding can be seen from the figure, where state 1 yields a higher effort gain than state 2 when the GP exerts "high effort" below the target and when s(he) exerts "low effort" above the target.

Figure 3: Effect of increasing effort on the probability of reaching the target at different effort levels as uncertainty increases



Notes: The target ν_0 is the case where the GP exerts effort below target. The target ν_1 is the case where the GP exerts effort above target. In state 1 the variance of the potential shock to performance is σ_1^2, which is marginally lower than the variance of a potential shock in state 2, σ_2^2, i.e. $\sigma_1^2 < \sigma_2^2$

Thus, from figure 2 and 3 it is seen that the GP's uncertainty's effect on his or her responds to a target performance payment depends on two factors: his or her degree of uncertainty and his or her effort's distance from the target level. In Appendix B this dependence is formally proven. It is found that the squared distance between the target level and the GP's effort level compared to the size of the variance of the shock determines how an increase in uncertainty affects the GP's incentives to increase effort. This finding is stated in the following proposition:

Proposition 4. *Given a target-based performance payment, the way an increase in the general practitioner's uncertainty about own performance affects his or her optimal effort depends on the* *general practitioner's degree of uncertainty and the distance from his or her effort to the target level. This finding gives rise to the following observations,*

a) If the squared distance from the general practitioner's effort level to the target level is larger than the variance of the shock, i.e. $(\nu - \alpha_i e_i)^2 > \sigma^2$*, then a marginal increase in the variance of the shock increases the general practitioner's gain from exerting effort, i.e.* $\frac{\partial^2 E u_i}{\partial e_i \partial \sigma^2} > 0$.

b) If the squared distance from the general practitioner's effort level to the target level is smaller than the variance of the shock, i.e. $(\nu - \alpha_i e_i)^2 < \sigma^2$*, then a marginal increase in the variance of the shock decreases the general practitioner's gain from exerting effort, i.e.* $\frac{\partial^2 E u_i}{\partial e_i \partial \sigma^2} < 0$.

c) If the squared distance from the general practitioner's effort level to the target level is equal to the variance of the shock, i.e. $(\nu - \alpha_i e_i)^2 = \sigma^2$*, then a marginal increase in the variance of the shock does not alter the general practitioner's gain from exerting effort, i.e.* $\frac{\partial^2 E u_i}{\partial e_i \partial \sigma^2} = 0$.

4.3.3 Amount of effort and size of the performance payment

As previously stated, the size of the payment for performance also influences the amount of effort a GP chooses to exert both when certain and uncertain about the effort-performance relationship. In the case of certainty about the effort-performance relationship, the size of the payment may, however, only affect a GP otherwise exerting effort below the target level (type 1 GPs). This finding is because a type 2 GP is not rewarded for increasing effort, because s(he) is already guaranteed the performance reward. The higher the payment, the more likely it is that a type 1 GP finds it profitable to increase effort as a response to P4P, cf. Equation 5.

In the case of uncertainty about own performance, all types of GPs respond to P4P by increasing effort as stated in Observation 2. The larger the payment, the more effort they are willing to exert so as to increase the probability of reaching the target, cf. Equation 7. This finding is articulated in the following observation,

Observation 3. *When general practitioners are certain about own performance, a larger performance payment increases the amount of general practitioner types, who perform below the target effort level, finding it profitable to increase effort. When general practitioners are uncertain about own performance, a larger performance payment causes all types of general practitioners to exert more effort.*

Section 4 analysed how a GP's uncertainty about the effort-performance relationship affects his or her response to the introduction of a target performance payment. The results can be summed up as follows: Introducing a performance payment under uncertainty leads all types of GPs to increase their effort. Hence, more GPs react to the performance payment, when they are uncertain about the effort-performance relationship. However, this finding does not necessarily mean that more effort is exerted when there is uncertainty as fewer types of GPs to choose exert enough effort to reach the target level under uncertainty. Whether uncertainty increases or decreases the total amount of effort exerted depends on the size of the performance payment, the degree of uncertainty, and on the distribution of GP types, i.e. their inherent abilities and preferences.

5 Conclusions

The purpose of this paper was to study how physicians respond to a target-based P4P scheme and how uncertainty about own performance may affect this outcome. A principal-agent model is used to investigate the effect of the target-based payment scheme with and without uncertainty. Although the behaviour of self-employed GPs is modelled, the findings extend to other physicians.

It is found that GPs' response to the introduction of the P4P scheme depends on their degree of uncertainty about own performance, the size of the performance payment, inherent ability to perform, and their preferences for leisure and provision of quality health care. If GPs can perfectly predict their performance only GPs otherwise choosing to exert effort below the target level may respond to the performance payment. These GPs' respond by increasing effort just enough to meet the target level. In contrast, when GPs are uncertain about their own performance, they all increase effort as a response to the performance scheme. Thus, more types of GPs increase effort when they cannot perfectly predict the effort-performance relationship.

Although this uncertainty causes more types of GPs to increase their effort, the total amount of exerted effort does not necessarily increase because uncertainty makes it less attractive for some types of GPs to exert effort at the target level. The analysis shows that whether uncertainty increases or decreases the total amount of effort exerted depends on the size of the performance payment, the degree of uncertainty, and on the distribution of GPs' types.

The insight from the analysis is that health care payers should initially consider the distribution of GP types when deciding on: 1) where to set the target, 2) the size of the payment, and 3) the allowed amount of uncertainty about the effort-performance relationship. This result underlines the importance of carrying out baseline performance measurements before introducing a target-based performance scheme and to assess the ability to predict own performance.

The analysis also shows that GPs' uncertainty about the effort-performance relationship may be an attractive instrument to create an efficient target-based performance scheme. If the health care payers believe that many GPs already perform above target or that many find the target infeasible to reach, then they may improve efficiency of the scheme by ensuring a high degree of uncertainty. A way to control GPs' degree of uncertainty could be to decide whether they should receive monitoring reports on their performance (and the frequency of such a status) and also whether their performance should be tied to indicators that are dependent on patient compliance. Furthermore, it is important to note that uncertainty may vary with GPs' experience with the performance system; hence, GPs' response to the target-based performance scheme may vary over time.

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A Proof of proposition 3 (case of uncertainty)

Proof. Recall that the GP's uncertainty about the effort-performance relationship is characterised by a random shock that is normally distributed with mean zero, i.e. $N \sim \left(0, \sigma^2\right)$. The change in the GP's expected utility gain from increasing effort from when s(he) was merely paid a fixed salary, $u_i^{s\,\prime}\left(e_i^s\right)$, to when offered P4P, $E\left[u_i^{p\,\prime}\left(e_i^s\right)\right]$, is:

$$Eu_i^{p\,\prime}\left(e_i^s\right) - u_i^{s\,\prime}\left(e_i^s\right) = \rho\alpha_i p_e'\left(\alpha_i e_i^s, \sigma^2\right), \text{ where } p_e'\left(\alpha_i e_i^s\right) > 0$$

The term $\alpha_i p_e'\left(\alpha_i e_i^s, \sigma^2\right)$ is the change in the GP's probability of receiving P4P, when increasing effort marginally, which is given by the probability distribution function of the normal distribution:

$$p_e'\left(\alpha_i e_i, \sigma^2\right) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(\nu-\alpha_i e_i)^2}{2\sigma^2}} > 0$$

Take the derivative of this expression with regards to effort yields:

$$\begin{aligned}\frac{\partial^2 p\left(\alpha_i e_i, \sigma^2\right)}{\partial^2 e_i} &= \frac{(\nu-\alpha_i e_i)}{\sigma^3\sqrt{2\pi}} e^{\frac{-(\nu-\alpha_i e_i)^2}{2\sigma^2}} > 0 \; for \; \alpha_i e_i < \nu \\ \frac{\partial^2 p\left(\alpha_i e_i, \sigma^2\right)}{\partial^2 e_i} &= \frac{(\nu-\alpha_i e_i)}{\sigma^3\sqrt{2\pi}} e^{\frac{-(\nu-\alpha_i e_i)^2}{2\sigma^2}} < 0 \; for \; \alpha_i e_i > \nu\end{aligned}$$

This result means that the closer to the target effort level the GP exerts effort, the more is the probability of reaching the target increased by an increase in effort. Thus, the expected utility gain from exerting more effort increases the closer to the target level s(he) exerts effort, i.e. $\frac{\partial^2 Eu(e_i^s)}{\partial^2 e_i} > 0$ for $\alpha_i e_i^s < \nu$ and $\frac{\partial^2 Eu(e_i^s)}{\partial^2 e_i} < 0$ for $\alpha_i e_i^s > \nu$. □

B Proof of proposition 4

Proof. Recall that the GP's uncertainty about the effort-performance relationship is characterised by a random shock to performance, which is normally distributed with mean zero, i.e. $N \sim \left(0, \sigma^2\right)$. Furthermore, the GP has no expected utility gain from increasing effort when having found the optimal effort level, e_i^u, when paid for performance:

$$Eu_i'\left(e_i^u\right) = \gamma_i h'\left[\alpha_i e_i^u\right] + \rho\alpha_i p_e'\left[\alpha_i e_i^u, \sigma^2\right] - c_i'\left[e_i^u\right] = 0$$

If uncertainty rises, the change in probability of reaching the target is the only variable that is altered. The change in the GP's probability of reaching the target, $\alpha_i p_e'\left(\alpha_i e_i^u\right)$, when increasing effort marginally is thus given by the probability distribution function of the normal distribution:

$$p_e'\left(\alpha_i e_i, \sigma^2\right) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-\left(\nu - \alpha_i e_i\right)^2}{2\sigma^2}} > 0$$

Now let the variance of the shock increase marginally. This increase affects the probability of reaching the target when effort increases marginally:

$$\frac{\partial^2 p\left(\alpha_i e_i, \sigma^2\right)}{\partial e_i \partial \sigma^2} = \left(\frac{\left(\nu - \alpha_i e_i\right)^2}{\sigma^2} - 1\right) \frac{\sqrt{2} e^{\frac{-\left(\nu - \alpha_i e_i\right)^2}{2\sigma^2}}}{2\sqrt{\pi}\sigma^2} \gtrless 0$$

Thus, the change in magnitude of the probability of crossing the target is $\frac{\partial^2 p\left(\alpha_i e_i, \sigma^2\right)}{\partial e_i \partial \sigma^2} > 0$ if $\left(\nu - \alpha_i e_i\right)^2 > \sigma^2$. This result means that when the squared distance between the target effort level and the GP's effort is larger than the variance of the shock, then the increase in the probability of reaching the target as effort increases, increases as uncertainty rises. However, when the squared distance in effort is less than the variance of the shock, the increase in the probability of reaching the target as effort increases, decreases as the variance of the shock rises, i.e.ă$\frac{\partial^2 p\left(\alpha_i e_i, \sigma^2\right)}{\partial e_i \partial \sigma^2} < 0$ if $\left(\nu - \alpha_i e_i\right)^2 < \sigma^2$. Thus, there exists an effort level, where there is no change in the effect of increased effort on the probability of reaching the target as uncertainty about performance increases marginally, i.e. $\frac{\partial^2 p\left(\alpha_i e_i, \sigma^2\right)}{\partial e_i \partial \sigma^2} = 0$ if $\left(\nu - \alpha_i e_i\right)^2 = \sigma^2$.

The results implies that the closer to the target the GP exerts effort, the more likely it is that an increase in the variance of a shock decreases the marginal utility of exerting effort, i.e. $\frac{\partial^2 Eu_i}{\partial e_i \partial \sigma^2} < 0$. Whereas the further away from the target s(he) exerts effort, the higher probability there is that an increase in the variance increases the marginal utility of exerting effort, i.e. $\frac{\partial^2 Eu_i}{\partial e_i \partial \sigma^2} > 0$. □