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Entrepreneurial Optimism and Creative Destruction

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Entrepreneurial optimism and creative destruction*

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Abstract

We provide empirical evidence that uncertainty (rather than risk) and optimism are distinctive characteristics of high-impact entrepreneurial firms (recently listed firms) relative to old, incumbent firms. Based on this evidence, we construct an entrepreneurial entry predation model with uncertainty. We show that entrepreneurial optimism can mitigate problems associated with strong incumbents' attempts to protect markets using predatory threats. Entrepreneurial optimism can also create a strategic advantage for entrepreneurs since incumbents may react by being less aggressive in product market interactions, which will benefit not only the profitability of the entrepreneur's venture but also consumers via lower prices.

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1 Introduction

High-impact entrepreneurial firms such as Google, Amazon, Vestas, Spotify, Uber, Tesla and Skype are a key element of the creative destruction process. These firms drive innovation, spark the revitalization of mature industries, and may even create new industries in the process – often against the strong resistance of incumbent players. The starting point of this paper is that a key difference between such high-impact entrepreneurial firms and incumbents is that the former operate under conditions of *uncertainty* rather than *risk*. Under *uncertainty*, decision makers do not have access to information that would allow them to form a unique probabilistic description of their decision situation. This distinction between *risk* and *uncertainty* has a long tradition in the entrepreneurship literature that goes back to at least Knight (1921).

Almost as old as the distinction between risk and uncertainty is the idea that entrepreneurs are more apt at handling uncertainty than others. Recent evidence supports this notion. For example, Butler (2017) finds that 'thriving under uncertainty' is a key factor that distinguishes entrepreneurs from managers. Evidence in Holm et al. (2013) suggests that entrepreneurs might be particularly inclined to engage with strategic uncertainties. In an interview with *Foreign Affairs* (January/February 2015), Niklas Zennstrom, co-founder of Skype, highlights this aspect of entrepreneurship. According to him, the most important quality of an entrepreneur is handling uncertainty because "you are trying to do something that no one has done before [...]".

A first contribution of our paper is to investigate whether high-impact entrepreneurial firms face uncertainty and are optimistic. To this end, we use automatic textual analysis of key sections of annual reports to build measures of risk, uncertainty, and optimism towards uncertainty for a large panel of U.S. firms between 1995 and 2015. We define high-impact entrepreneurial firms as recently listed firms measured by the number of years since the firm made its Initial Public Offering (IPO). We argue that the listing period is the crucial moment in the creative destruction process, as it is decided whether a firm will be able to compete with the incumbents on a large scale and become a high-impact entrepreneurial firm. Our measures of risk and uncertainty are based on applying the method developed in Friberg and Seiler (2017) to the *Business Description* section of firms' annual reports. Lastly, we measure optimism towards uncertainty by calculating the tone of forward-looking statements in the *Management, Discussion & Analysis* section of annual reports. We establish two main results.

First, when describing their business, recently listed firms use more uncertainty-based terms than older firms. We find that the ratio of uncertain to risky terms to describe a firm's business drops 20% in the first five years since it becomes public. This pattern is robust to a stringent regression specification in which we control for year and firm fixed effects and a proxy for firms' investment opportunities.

Second, in forward-looking statements, recently listed firms use a significantly more optimistic tone than older firms. The forward-looking tone drops by 10% in the first five years since a firm became public. The result is again robust to a stringent regression specification controlling for firm and year fixed effects and investment opportunities. We take this as evidence that uncertainty and optimism are two characteristics of high-impact entrepreneurial firms.

To capture these key characteristics of high-impact entrepreneurial firms and to examine their impact on the efficiency of the creative destruction process, we propose an entrepreneurial entry predation model with uncertainty. The uncertainty arises because the entrepreneur faces an incumbent that might protect its market using predatory behaviour. We allow the entrepreneur to be more or less optimistic towards that uncertainty by applying a special case of the decision maker that was axiomatized in Schmeidler (1989) and developed in Chateauneuf et al. (2007): when making a decision, our uncertainty-sensitive decision maker weighs the best and the worst cases together with expected profits to calculate her utility. This specification has the advantage of being tractable while simultaneously maintaining some of the key aspects of decision making under the uncertainty observed in experiments.[1] Depending on the weights attached to the different

[1]Recent evidence by Holm et al. (2013) suggests that entrepreneurs might be particularly inclined to engage with strategic uncertainties, but these authors find no differences in risk taking for non-strategic uncertainties. Koudstaal et al. (2015) suggest that entrepreneurs might be particularly well situated to handle predation and competitive threats since they find that entrepreneurs put less weight on bad outcomes. Thus, in our proposed model, we focus on the role of entrepreneurial optimism in strategic situations under uncertainty.

cases, the entrant is more or less optimistic towards uncertainty.

Our theoretical analysis reveals several noteworthy insights. We show that if the entrepreneur is sufficiently optimistic, entry occurs even when an expected profit maximizer would not want to enter. Even though entry is excessive from an expected profit perspective, the associated gains in consumer rents from increased product market competition can outweigh the expected loss for the entrepreneur such that overall welfare might increase.

The entrepreneur's attitude towards uncertainty will also affect her behaviour in the product market. More-optimistic entrepreneurs act more aggressively in market competition than expected profit maximizers. This situation reduces the price in the product market but allows the entrepreneur to capture a larger market share since the incumbent reacts by being less aggressive.[2] For some degrees of optimism, the gains from a larger market share outweigh the accompanying drop in price. Thus, when entry is not profitable for an expected profit maximizer, an optimistic entrepreneur might still successfully enter because her optimism allows her to achieve larger profits in product market interactions. In such cases, industry profits decrease, consumer rents increase and welfare may increase.

This paper contributes to the literature on entrepreneurship and welfare (for overviews, see Acs and Audretsch (2005) and Bianchi and Henrekson (2005)). The process of creative destruction and its welfare implications have been extensively studied in the case of perfect information and in situations where the entrepreneurs face risk.[3] However, the literature examining entrepreneurship and optimism is sparse and generally focuses on the negative impact of optimism. For example, De Meza and Southey (1996) and De Meza (2002) show that entrepreneurial optimism can lead to excessive lending. Parker (2007) proposes a model of credit markets under asymmetric information in which individuals differ in abilities that are valued in both entrepreneurship and paid employment and

[2] The intuition behind this strategic effect can be found in Schelling (1980), Vickers (1985) and Fershtman and Judd (1987).

[3] See, for instance, Arrow (1962), Aghion and Howitt (1992), Gilbert and Newbery (1982) and Norbäck et al. (2016).

therefore under-investment and credit rationing can occur instead.[4] We add to this literature by showing how entrepreneurial optimism can improve the creative destruction process by curbing incumbents' opportunity to protect their markets, to the benefit of consumers. In this vein, we believe that we are able to combine the crucial elements of the entrepreneur in industrial development proposed by Knight (1921) and Schumpeter (2008).

Our paper also adds to the literature on optimism and firm behaviour more generally. Most papers have investigated the implications of optimistic CEOs (Malmendier and Tate, 2005; Malmendier et al., 2011; Galasso and Simcoe, 2011; Hirshleifer et al., 2012; Deshmukh et al., 2013; Otto, 2014). In this literature, optimism is measured either as a function of CEOs' option holding behaviour (Malmendier and Tate, 2005) or the unexplained part of earnings forecasts (Otto, 2014) or by scanning the business press for clues on optimistic CEOs (Malmendier and Tate, 2008). In this paper, we suggest an alternative measure of optimism that is based on textual analysis of the forward-looking statements in the management discussion section of annual reports, which is mandatory for all public firms. We show that optimism measured as such is particularly prevalent among recently listed firms.

The structure of our paper is as follows: we begin with the empirical motivation based on the textual analysis of annual reports. We then present a basic model of entrepreneurial entry and show how the introduction of uncertainty sensitivity changes the analysis. We then extend this model by explicitly modelling product market interactions under uncertainty. The last section offers our conclusions.

[4]In the game theory literature, the positive aspects of behavioural distortions are investigated by focusing mostly on individual wellbeing: Heifetz et al. (2007) show that in almost every game and for almost every family of distortion of a player's actual payoffs, some degree of this distortion is beneficial to the player and will not be driven out by evolutionary processes. Khachatryan and Weibull (2011)show that entrepreneurs with overconfidence can form an evolutionarily stable equilibrium in Cournot games. An exception is the paper by Bernardo and Welch (2001), who show that groups with optimistic agents can have an advantage in information acquisition.

2 Empirical part

In this section, we present our results on the relation between risk, uncertainty, and optimism in high-impact entrepreneurial firms (recently listed firms) versus older incumbent firms. We describe our data in Section 2.1. In Section 2.2, we discuss our measurement approach to construct indices of risk, uncertainty and optimism. We present the results of our analysis in Section 2.3.

2.1 Data

Our data build on Compustat firms between 1995 and 2015. Using the quarterly master index files available from the Securities and Exchange Commission (SEC), we identify and download all annual reports filed with the SEC between 1995 and 2015. We isolate the text in the reports following best practices outlined in Loughran and McDonald (2016) and split it into its individual sub-sections.[5] We use the textual information to construct measures of risk, uncertainty and optimism; the details of our approach are provided in the next section. We match the resulting indices to the accounting data using the WRDSlinking tables. For our final sample, we drop financials and utilities, as well as firms with negative assets and sales. Table 1 provides an overview of our dataset.

[Table 1 here]

Most variables we use in our empirical part are based on a textual analysis of annual reports. We explain them only quickly here and refer to the next section for a more detailed discussion. *Uncertainty/Risk* is the ratio of uncertain terms to risk terms in the business description section of annual reports. The *Uncertainty Share* and *Risk Share* are the shares of words referring to uncertainties or risks in the business description section. Because these shares are rather low, we express them in percentage points. The variable

[5] Our technical implementation builds on several open-source libraries. We use the JSOUP library (https://jsoup.org/) to parse the documents and the natural-language processing toolbox presented in Manning et al. (2014) for the textual analysis. To identify sub-sections in the raw text, we use regular expressions.

Forward Tone measures the tone of forward-looking statements in the discussion section of the annual reports.

We define *Age* as the number of years since a company went public. We believe that recently listed firms will be more likely to correspond to high-impact entrepreneurial firms than older firms. We obtain information on when a firm became public from the CRSP database.

To measure investment opportunities, we rely on the measure of *Total Q* presented in Peters and Taylor (2017). The measure differs from conventional proxies for investment opportunities because it explicitly takes intangible capital into account. Intangible capital has become increasingly important over the past thirty years (Corrado and Hulten, 2010) and is currently likely to be of particular importance for the high-impact entrepreneurial firms in which we are interested. Total Q is defined as the market value of outstanding equity plus the book value of debt minus the firm's current assets scaled by the sum of tangible and intangible capital.[6] Intangible capital is calculated using the perpetual inventory method on R&D expenditures defined as $XRD + 0.3SGA$. Tangible capital is $PPEGT$. In their paper, Peters and Taylor (2017) show that Total Q is a better proxy for investment opportunities than conventional measures. Total Q can turn negative when the value of outstanding equity and the book value of debt fall below the value of current assets. Our results are roughly identical when using conventional measures of investment opportunities. For more detail on Total Q, we refer to the original paper.

2.2 Measuring risk, uncertainty and optimism

Our measures of risk, uncertainty and optimism are based on the analysis of the business description and management discussion sections of annual reports. In the US, annual reports are highly structured documents which, by regulation, must contain a description of the business model of a firm and a discussion of its current and future activities. Our algorithms isolate the text contained in these sections to construct measures of risk, uncertainty and optimism.

[6]Formally, $(PRCC_F \times CSHO + DLTT + DLC - ACT)/(K_I + K_T)$.

To measure whether a firm is more exposed to *risk* or *uncertainty*, we analyse how firms describe their businesses. For this purpose, we use the word lists of Friberg and Seiler (2017) and calculate the share of terms associated with risk or uncertainty in a company's business description (Item 1). The word lists are based on the dictionary of uncertain tone developed in Loughran and McDonald (2011), but each word is additionally classified as either referring to *risk* or *uncertainty* based on a small set of intuitive principles. Risky terms refer to objective probabilities "variance", "volatility" or "frequently", while terms referring to subjective probabilities (e.g., "believe", "perhaps"), ambiguous outcomes (e.g., "ambiguous","indeterminate") or "unknown unknowns" (e.g., "sudden","unforeseen") are classified as *uncertainty*.

We define three indices of risk and uncertainty based on our data. First, for each firm and fiscal year, we calculate the ratio of uncertainty words to risk words in the business description section. This ratio tells us whether a firm is more exposed to the former or to the latter in a given year. Second, we calculate the share of risk and uncertainty words in the business description section, which allows us to disentangle whether our results using the ratio of uncertainty terms to risk terms are driven by either category. We look at the shares and not the absolute numbers because absolute numbers have increased simply because annual reports became longer.

Our measure of optimism is the ratio of positive to negative terms in forward-looking statements in the Management, Discussion & Analysis (MDA) section of annual reports. In this section, management is required to give their view on the firm's current and future performance. We identify forward-looking statements as sentences that contain at least one forward-looking term from the list in Athanasakou and Hussainey (2014). In each of these sentences, we calculate the ratio of positive to negative terms, which is a common measure for the tone of a statement. The list of positive and negative words stems from the dictionaries developed by Loughran and McDonald (2011), who pay special attention to the fact that the meaning of words differs from common language when used in a financial context. We then average the result for each firm and fiscal year to obtain our measure of optimism.

The tone in forward-looking statements can be positive either because a firm has strong growth opportunities or because of optimism. To account for this possibility, we will control for investment opportunities in all our regressions, removing the variation in our tone measure that is due to growth expectations. The remaining variation is what, given our measure of investment opportunities, is attributable to optimism on the management side.

2.3 Empirical results

Uncertainty and optimism are particularly high among recently listed firms, as illustrated in Figure 1. The left panel shows how the ratio of uncertainty words to risk words in the business description section of annual reports diminishes as firms age. The right panel shows our tone measure: the ratio of positive to negative terms in forward-looking statements found in the MD&A section of annual reports. The series is more volatile than the ambiguity-risk ratio because forward-looking statements are only a small part of the MD&A section – the data are thus constructed on a much smaller text basis. Nevertheless, the graph suggests that recently listed firms use approximately the same number of positive and negative terms when talking about the future, but older firms tend to use much more negative terms.

While the graphs help to convey the key message of our analysis, they suffer from a number of caveats. The average patterns could be driven by exits from the pool of firms in our sample. For example, if exit were driven by firms in more ambiguous environments, this situation would explain the decline in the ratio of ambiguous to risky terms. It is also impossible to disentangle the extent to which the positive tone in the forward-looking statements of younger firms might be warranted by the larger investment opportunity sets that such firms exhibit.

We thus investigate the empirical relationship of uncertainty, risk and optimism to firm age using panel regression techniques. We run regressions of the following type:

$$Y_{it+1} = \beta \log(Age_{it}) + \gamma Q_{it} + \alpha_i + \gamma_t + e_{it}, \quad (1)$$

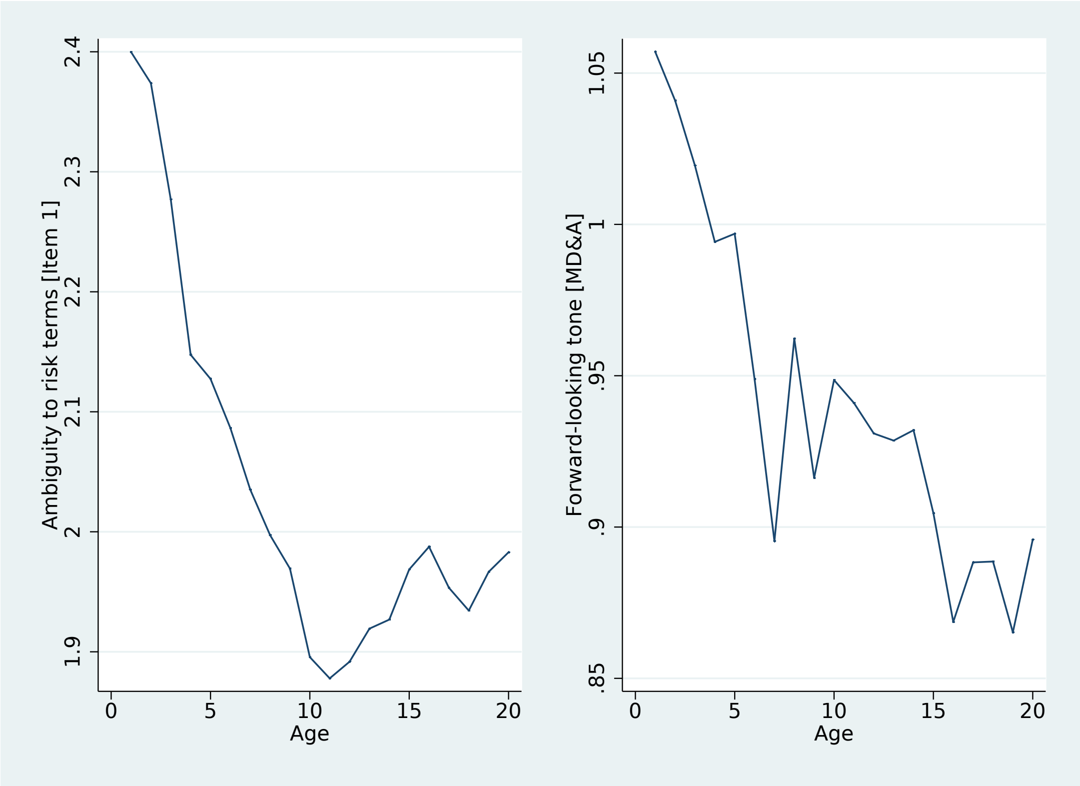

Figure 1: The left panel shows the average ratio of ambiguity terms to risk terms in Item 1, the business description section of annual reports, between 1995 and 2015, as a function of age. The right panel shows the ratio of positive to negative terms in the forward-looking statements of the MD&A as a function of age.

where i and t index firms and fiscal years, respectively. The outcome variable Y_{it+1} is a standardized index either for risk, uncertainty or optimism, with a one-period lead. We include Age_{it} as a log so that β can be interpreted as the percentage point change in investment rates when age doubles. The variable Q_{it} is the firm's contemporaneous value of Total Q, our measure of investment opportunities. We include firm α_i and time γ_t fixed effects. The variable e_{it} corresponds to the usual error term.

Our specification ensures that differences in reporting standards among firms are absorbed and that differences in investment opportunities between young and old firms do not drive our results. The firm fixed effects absorb differences in reporting standards across firms to the extent that they are time invariant. We also include time fixed effects to absorb changes in reporting standards over time. Total Q absorbs systematic differences in investment opportunities between young and old firms. We present the results of our analysis in Table 2.

[Table 2 here]

The ratio of uncertainty terms to risk terms falls systematically as firms age, as shown in the first three columns of Table 2. The first column shows that a doubling of age is associated with a reduction of the uncertainty-to-risk ratio by 0.14 standard deviations, which corresponds to a 10% reduction from the mean level in our sample. The second and third columns show that this decline is driven by a decrease in the share of uncertainty words in the business description sections. A doubling of age reduces this share by 0.12 standard deviations. The share of risk words increases at the same time, albeit only marginally. We interpret these results as observational evidence for the importance of uncertainty, rather than risk, early in a firm's life cycle.[7]

More uncertain business descriptions are associated with better investment opportunities, but the association is economically small. An increase in investment opportunities by one standard deviation is associated with an increase in the share of uncertain terms in the business description section of 0.013 standard deviations. This figure corresponds to an increase of roughly 0.5% from the mean, which is very small. However, there is literally no association between the share of risk terms in a business description and our measure of investment opportunities, as can be seen in the third column of Table 2.

Forward-looking tone is also positively related to investment opportunities. The standardized coefficient estimate is 0.03. In terms of deviation from the mean, a one-standard-deviation increase in Total Q improves the tone in forward-looking statements by roughly 4%. Changes in tone thus significantly depend on firms' investment opportunities, as we would expect. However, there is also substantial variation in tone that is not related to investment opportunities. We interpret this variation as indicative of firm optimism.

Tone in forward-looking statements is more positive for young firms after controlling for investment opportunities, as shown in the last column of Table 2. As an outcome variable, we now use the tone of the forward-looking statements found in the MD&A sections. We find that a doubling of age is associated with a decrease in tone by 0.09

[7]The high R-squared in the regressions using our risk and uncertainty measures is due to year fixed effects absorbing the general trend towards longer annual reports. The length of annual reports over our sample period has roughly tripled. Fiscal year fixed effects in our regressions absorb these effects.

standard deviations. Compared to the mean tone, this figure indicates a reduction of approximately 10%. Young firms are thus more likely to exhibit a positive tone in their forward-looking statements that cannot be explained by their investment opportunities.

In this section, we provided evidence that suggests uncertainty (rather than risk) is important for high-impact entrepreneurial firms. We use the years since the firm was listed on the stock market as a proxy for high-impact entrepreneurial firms and show that recently listed firms exhibit a more positive tone in their forward-looking statements that cannot be explained by their higher investment opportunities. To capture these key characteristics of high-impact entrepreneurial firms and to examine their impact on the efficiency of the creative destruction process, we propose an entrepreneurial entry predation model with uncertainty. Our model will allow us to explore the implications of these two features in terms of firm performance and welfare.

3 Base model

The basic setup of our model consists of two players, an incumbent I and a potentially uncertainty-sensitive entrepreneur E. The entrepreneur can decide to enter the market or not. The incumbent can decide to fight the entrant or to accommodate her. The entrepreneur can either be an expected profit maximizer R or a risk-neutral but uncertainty-sensitive agent O in the spirit of the theoretical literature on ambiguity attitudes following Schmeidler (1989) and Gilboa and Schmeidler (1989). We will discuss this type in detail in Section 3.1. The incumbent is always assumed to be a profit maximizer but can find it easier or harder to try entry-deterring behaviour. She could be tough T with probability p, in which case, she faces no costs when she tries to deter entrants. Alternatively, she could be soft S with probability $1 - p$, in which case, she pays a cost C if she wants to deter entry. We proceed by presenting the timing and payoff structure of our model and end with a discussion of some of our key simplifying assumptions.

The timing of our model is as follows. In stage zero, nature sets the incumbent's type. In the first stage of the game, the entrepreneur can, without knowing the incumbent's type, decide whether she wants to enter the market. She expects to meet a tough opponent with probability p. In stage 2, the incumbent decides to deter or accommodate entry. In the third and last stage, the entrepreneur and the incumbent interact in the product market if entry has occurred. We illustrate this in Figure 2.

[Figure 2 here]

The incumbent's decision to deter entry has two effects: (i) it increases the costs of the entrant from zero to F and (ii) it yields a direct benefit to the incumbent, for example, through weaker competition in future periods of market interactions (see Ordover and Saloner (1989)).[8] The benefits could also stem from higher variable costs of the entrepreneur that are potentially due to a weaker patent, to the incumbent hiring key employees from the entrepreneur or to predatory pricing that increases the financial costs of the entrepreneur. We choose not to model these trade-offs explicitly in order to keep our model simple. We assume $F > \pi_E$, such that the entrepreneur would have preferred to stay away from the market if the incumbent chose deterrence.

Our assumptions imply that the tough incumbent will always predate and the soft incumbent never will. Because the tough type faces no costs of predation, assuming a benefit of predation will lead her to always predate. For the soft type, we also assume that predation will never be profitable, i.e., $C > \pi_I^M - \pi_I^D$. This expression effectively determines the behaviour of the incumbent and allows us to focus on the behaviour of the entrepreneur, which is of key interest in this paper.

It remains to define the profits in the product market interaction in order to determine the final payoffs in the model. The incumbent earns π_I^M if the entrepreneur did not enter in stage 1 and π_I^D if the entrepreneur did enter, where $\pi_I^M > \pi_I^D > 0$. The entrepreneur's profit is $\pi_E > 0$ if it entered in stage 1 and 0 otherwise. Market entry costs F are sunk. Therefore, the entrepreneur will compete and earn $\pi_E > 0$ once she decides to enter, irrespective of the incumbent's actions. Together with the deterrence and entry costs, this determines the final payoffs, as illustrated in Figure 2.

[8] The benefits of deterrence can be thought of as an additive parameter ε in the incumbent's payoff function that is normalized to zero.

So far, we have made two key simplifying assumptions. First, we assume the incumbent is always an expected profit maximizer, but she can find it easier or harder to deter entry. Second, the incumbent knows the entrepreneurial type, but not vice versa. We will now discuss these assumptions in more detail.

There are several reasons to assume that the incumbent is an expected profit maximizer. First, large incumbents are often organized in limited liability companies with more dispersed ownership, whose shared interest is to induce managers to maximize profits. Second, in many countries, the law for limited liability firms states that the firm should maximize shareholder value. Third, corporate governance mechanisms and well-designed incentive contracts might tame the potential behavioural traits of managers. Finally, we have shown in our empirical section that an excessively positive tone is a characteristic feature of younger firms, which suggests that optimism is particularly prevalent among entrants but not among incumbents.

Incumbents might find it easier or harder to deter entry depending on their institutional setup. We can imagine that the tough type will have access to a better legal department when taking the entrant to court, will have a better marketing department that can more efficiently start a marketing war, or will be less concerned about the risk of the anti-trust authorities making a case of predatory behaviour.

The entrepreneurial type is known to the incumbent, but the incumbent's type is not known to the entrepreneur. A richer model would allow for the entrepreneurial type to be only privately known. Such a model would exhibit separating equilibria, where only one type of agent enters, or pooling equilibria, where both type of agents enter. Our assumption effectively excludes the second case and makes us focus on the former. We will leave a detailed analysis of the pooling case to future research but will sketch how our analysis would change where appropriate.

3.1 Entry pattern and optimism

In this section, we show how introducing uncertainty-sensitive entrepreneurs changes the analysis of a basic entry game. In situations of uncertainty, optimistic entrepreneurs enter markets that expected profit maximizers would not enter. We show that the timing of decisions and how uncertainty evolves through the game is important to obtain differential behaviour between expected profit-maximizing and uncertainty-sensitive entrepreneurs at all. We will spell out the conditions under which we expect such differences to occur in detail.

In the following analysis, an important distinction will be between an entrepreneur's perceived profits $\tilde{\pi}_E^i$ and her expected profits π_E^i where $i \in \{R, O\}$. In the case of expected profit maximization, these two concepts always coincide.[9]

The entry decision of the expected profit-maximizing entrepreneur R is straightforward. She enters the market whenever she expects to make a positive profit, taking into account the probability of facing a tough incumbent

$$\pi_E^R = \pi_E - pF > 0.$$

To model the uncertainty-sensitive type O, we make use of the decision model suggested in Schmeidler (1989) with some additional assumptions by Chateauneuf et al. (2007). This framework allows the uncertainty-sensitive type to believe that a whole set of probabilities could describe the likelihood of meeting a tough type. It is rooted in a rigorous axiomatization, is highly tractable and still maintains key aspects of decision-making under uncertainty observed in experiments. The objective function of our uncertainty-sensitive entrepreneur is given by

$$\tilde{\pi}_E^O = \delta[\alpha\pi_E^{max} + (1-\alpha)\pi_E^{min}] + (1-\delta)\pi_E^O, \tag{2}$$

where π_E^{max} and π_E^{min} are the best and worst cases that the agent believes could occur and π_E^O is the profit she would expect based on risk alone. The weights attached to individual elements are determined by two parameters α and δ, which both lie in the interval $[0, 1]$. The parameter δ is a measure of how uncertain the agent is about her

[9] Because we are interested primarily in the effects of uncertainty and uncertainty attitudes, we will assume risk neutrality throughout the paper. Risk preferences can be easily represented by introducing some concavity in the evaluation of the monetary outcomes. This step would not affect the basic mechanisms we present but would make their exposition algebraically more challenging.

probability assessment p. A higher δ leads to less weight on the expected profit and puts more weight on both the best and worst cases. The parameter α determines how this additional weight is distributed between the best and worst cases. Chateauneuf et al. (2007) suggests that α be interpreted as the agent's uncertainty attitude or as a parameter of optimism and pessimism. A higher α results in a higher weight on the best possible outcome and, thus, a more optimistic, uncertainty-affine or positive attitude.

In our basic model, the perceived profit of entrepreneur O collapses to a simple expression. The best case is achieved when no predation occurs, while the worst case is achieved when predation occurs and the expected profit is based on the central probability assessment p for meeting a tough incumbent. Entry occurs if the perceived profit is larger than zero ($\tilde{\pi}_E^O > 0$). Note that the "expected" profits will still be given by $\pi_E^O = \pi_E - pF$, which will in general not be equal to the perceived profits $\tilde{\pi}_E^O$. We can summarize this situation as:

$$\begin{aligned}\tilde{\pi}_E^O &= \delta[\alpha \underbrace{\pi_E}_{\pi_E^{max}} + (1-\alpha) \underbrace{(\pi_E - F)}_{\pi_E^{min}}] + (1-\delta) \underbrace{[(1-p)\pi_E + p(\pi_E - F)]}_{\pi_E^O} \\ &= \pi_E - \delta(1-\alpha)F - (1-\delta)pF. \end{aligned} \tag{3}$$

Regardless of the specifics of the entry game, it will always be possible to find an uncertainty-sensitive entrepreneur who enters the market, even if a expected profit maximizer would not want to enter it. Formally, we show for each level of uncertainty δ and a given market structure π_E and F that if the uncertainty attitude $\alpha \in [0,1]$ is high enough, the uncertainty-sensitive entrepreneur will be at least as likely to enter the market as the expected profit maximizer. However, the actual level of this uncertainty attitude depends on the specific market structure in question. We summarize this situation in the following proposition:

Proposition 1 *For all uncertainty levels δ and market structures π_E and F, there exists an uncertainty attitude $\alpha \in [0,1]$ such that the range of probabilities of meeting a tough incumbent at which the uncertainty-sensitive agent would enter is at least as large as the* *corresponding range of probabilities for the expected profit maximizer.*

Proof. See the Appendix. ■

The intuition of this result is illustrated in the upper diagram of Figure 6. The graph features the probability of meeting a tough opponent p on the x-axis and the perceived profits on the y-axis. Line R shows the perceived profits of an expected profit maximizer. The intercept is given by π_E, that is, the profits that will result in the product market interaction. With an increasing probability p of meeting a tough opponent, the expected profit decreases at rate F. Moreover, if the probability p becomes too large ($p > \frac{\pi_E}{F}$), the expected profit becomes negative, and the agent will decide not to enter the market.

[Figure 6 here]

For the uncertainty-sensitive type, the entry condition shifts up with higher optimism and becomes flatter with more uncertainty, which can be seen immediately in Equation 3. Increasing optimism will decrease the weight attached to the predation costs F, shifting the whole curve upwards. At the same time, the curve will be flatter whenever there is uncertainty ($\delta > 0$). The entry condition of a complete optimist ($\alpha = 1$) would have the same intercept as the entry condition of an expected profit maximizer, but its slope would be less negative because of the effect of uncertainty. The intercept would thus intersect the x-axis at a later point.

This result does not depend on how we specified the best and worst cases. Without explicitly specifying the best and worst cases, we can rearrange the uncertainty-sensitive entrepreneur's goal function as:

$$\tilde{\pi}_E^O = \underbrace{\delta[\alpha\pi_E^{max} + (1-\alpha)(\pi_E^{min})] + (1-\delta)\pi_E}_{\text{intercept}} - \underbrace{(1-\delta)F}_{\text{slope}}\, p.$$

How does this curve generally compare to the cut-off condition we have derived for the expected profit maximizer? First, we note that the intercept is given by a weighted average of π_E, π_E^{max} and π_E^{min}. Because $\pi_E^{\max}$ can be above π_E, the intercept of the entry condition can generally be higher for the uncertainty-sensitive type compared to the expected profit maximizer. Second, the intercept of the entry condition can also be affected by the uncertainty around meeting a tough opponent. Depending on the uncertainty attitude, more uncertainty can increase or decrease the intercept.

It is still possible to find a level of optimism under which the uncertainty-sensitive entrepreneur enters even though the expected profit maximizer will not. In the general case, more optimism still unambiguously shifts the entry condition up, potentially above the intercept of the entry condition for the profit-maximizing entrepreneur, and higher uncertainty makes the curve still flatter.[10] Speaking in terms of Figure 6: picking a high enough level of optimism in combination with some uncertainty will always make it possible for the entry condition of the uncertainty-sensitive entrepreneur to intersect the x-axis after the entry condition of the expected profit maximizer.

We formulate this idea in Lemma 1 more precisely, because we will rely on it when identifying the welfare-enhancing region of optimism in later sections. Under at least some uncertainty δ, we can always identify a cutoff on optimism α that guarantees us the highest probability of deterrence $p^O(\alpha)$ for which entry that occurs under optimism is at least as large as the corresponding highest probability p^R under expected profit maximization.

Lemma 1 *For $\delta > 0$ and any market structure π_E and F, if $\alpha > \overline{\alpha} = -\frac{\pi_E^{min}}{\pi_E^{max} - \pi_E^{min}}$, then $p^O(\alpha) > p^R$ and the uncertainty-sensitive agent enters situations that the expected profit maximizer would not enter. The opposite occurs if $\alpha < \overline{\alpha} = -\frac{\pi_E^{min}}{\pi_E^{max} - \pi_E^{min}}$; then, the uncertainty-sensitive agent does not enter situations that the expected profit maximizer would enter.*

Proof. See the Appendix. ■

There are several noteworthy observations. First, the cutoff condition is binding only when the worst-case result is negative. Specifically, with $\pi_E^{min} = \pi_E - F$ and $\pi_E^{max} = \pi_E$, the condition reduces to $\overline{\alpha} = 1 - \frac{\pi_E}{F}$, which, given our assumptions, will always lie in

[10]To see this situation, note $\frac{d\pi_E}{dp} = -F < \frac{d\widetilde{\pi}_E^O}{dp} = -(1-\delta)F < 0$.

the interval from 0 to 1. Second, if the spread between the best outcome and the worst outcome is large, optimism has more bite and the cutoff condition $\bar{\alpha}$ is lower, which corresponds to the fraction $\frac{\pi_E}{F}$ being large. Third, agents with high enough uncertainty attitudes ($\alpha > \overline{\alpha}$) act optimistically by sometimes entering markets in which they face negative expected profits. The flip side of this result is that agents with low enough uncertainty attitudes ($\alpha < \overline{\alpha}$) act pessimistically by sometimes not entering markets in which they could earn positive profits.

Let us now turn to the role of commitment and the timing of decisions. They are important because they determine the evolution of uncertainty. Uncertainty and optimism matter only for the outcome of the entry game, when the decisions made under uncertainty are not reversible once uncertainty is removed. We state this situation in the following proposition.

Proposition 2 *If the incumbent can commit to deterrence or the entrepreneur has an exit option after the incumbent decides on deterrence, there will be no behavioural differences between the uncertainty-sensitive and the expected profit-maximizing entrepreneur.*

Proof. See the Appendix. ■

To see this possibility, assume that both types of incumbents can credibly commit to deterrence before the entrepreneur's entry decision. In that case, all strategic uncertainty would be resolved and the best case, the worst case and the expected profits would coincide. Both entrepreneurial types would then perceive the same payoff structure when deciding on entry and would hence make the same decisions in equilibrium. Alternatively, assume that the entrepreneur is not committed to her entry decision. Instead of staying in the market and riding out any potential losses, she would be allowed to reconsider her decision after observing the incumbent's reaction to her initial choice. The decision to stay in the market or to walk away would again be made without any strategic uncertainty and, hence, the two entrepreneurial types would perceive the same payoffs and choose the same actions. In addition, the option to discontinue the game after the incumbent's choice eliminates all relevant downside risks at the initial entry decision, always making entry a good idea for both entrepreneurial types.

3.2 How optimistic entrepreneurship may increase welfare

We next turn to the analysis of consumer surplus and welfare. We will compare the expected consumer surplus (total surplus) differences between an economy with an expected profit-maximizing entrepreneur and an economy with an optimistic entrepreneur.[11] Thus, we assume that the uncertainty-sensitive entrepreneur is optimistic ($\alpha > \overline{\alpha}$) such that $p^O > p^R$. We also assume that there is some level of strategic uncertainty in the economy $\delta > 0$, which ensures that we obtain differential behaviour between the optimistic and the expected profit-maximizing entrepreneur.

A standard result in oligopoly theory states that prices decrease and quantities increase as more players enter a market. To capture this feature, we define the consumer rent before entry as CR^M and the ex post increase in consumer rent due to entry as $\Delta CR > 0$. The expected consumer surplus $E(CR^i)$ in economies with the respective entrepreneurial types $i \epsilon \{R, O\}$ will then be $p(CR^M + \Delta CR) + (1-p)(CR^M + \Delta CR)$ if entry occurs and CR^M if not.

$$E(CR^i) = \begin{cases} CR^M + \Delta CR & \text{if } p \leq p^i \\ CR^M & \text{if } p > p^i \end{cases} \quad \text{for } i \in \{R, O\}$$

We can then derive the following result:

Proposition 3 *The expected consumer surplus is at least as high in the economy with optimistic entrepreneurs as in the economy with expected profit-maximizing entrepreneurs.*

Proof. See the Appendix. ■

The basic intuition of this result is graphically illustrated in the lower diagram of Figure 6. The solid line corresponds to the expected consumer surplus in the economy with expected profit-maximizing entrepreneurs. At p^R, the line jumps to the lower level CR^M. In the case of an economy with an optimistic entrepreneur, the consumer surplus

[11] Another approach to a welfare evaluation of the effects of ambiguity-driven entrepreneurship would be to assume that the policy maker faces a distribution function over α and then compare the expected consumer surplus and the expected total surplus between an economy with profit-maximizing entrepreneurs and one with optimistic entrepreneurs.

line continues at $CR^M + \Delta CR$ until $p^O > p^R$ and only then jumps back to the monopoly level.[12]

Let us now turn to the effect on total surplus in the model. At the outset, there is the fundamental question of whether the producer surplus should be evaluated using the entrepreneur's perceived profits or her actual profits. Before strategic uncertainty is revealed, the optimistic entrepreneur values her entry option at $\max(\widetilde{\pi}_E^O, 0)$ – ex post, however, she would revise her assessment and value the entry option at $\max(\overline{\pi}_E^O, 0)$. From a social planner's perspective, it is not clear whether the ex ante or the ex post assessment should count in welfare analyses. To solve this dilemma, we chose the valuation approach that puts stricter conditions on welfare improvements. Since an optimistic entrepreneur will, by definition, perceive an option value of entry above the actual expected profits, we use the latter for welfare evaluations.[13] We can write welfare under each entrepreneurial economy type $i \in \{R, O\}$ as

$$E(W^i) = \begin{cases} [\pi_E + \pi_I^D] + CR^M + \Delta CR - pF & \text{if } p \leq p^i \\ \pi_I^M + CR^M & \text{if } p > p^i \end{cases}.$$

Total welfare is composed of three elements. The first element is the producer's surplus profits obtained in the product market interaction. In case of entry, this figure corresponds to the sum of the incumbent's and the entrepreneur's profit $\pi_E + \pi_I^D$; otherwise, it is equal to the monopoly profit π_I^M for the incumbent. The second element is the consumer surplus, which increases by ΔCR if entry occurs. From our analysis above, we know that this is the case if $p \leq p^i$ for $i \in \{R, O\}$. The last element is the expected entry cost pF from expected predation. This figure follows from the incumbent predating if and only if she is the tough type. The difference in welfare under the two types of economies is given by

[12] The expected consumer rent is downward sloping if we assume that predation leads to a default of the entrepreneur before she can actually serve the market; it might be upward sloping if we assume that predation occurred in the form of more aggressive product market behaviour. For a classification of different forms of predatory behaviour, see Tirole (1983).

[13] We can write $E(\widetilde{W}^O) = \widetilde{\pi}_E^O + \pi_I + CR^M + \Delta CR$ if $p \leq p^O$. Since $\widetilde{\pi}_E^O = \pi_E^R + \delta(1 - \alpha + p)F$, this can be rearranged to $E(\widetilde{W}^O) = E(W) + \delta(1 - \alpha + p)F$ if $p \leq p^O$. For an optimistic entrepreneur, it can be shown that the second term is larger than zero.

$$\Delta W = E(W^O) - E(W^R) = \begin{cases} \Delta CR + (\pi_E - pF) - (\pi_I^M - \pi_I^D) & \text{if } p \in]p^R, p^O[\\ 0 & \text{otherwise.} \end{cases}$$

The total welfare effect will be determined by three sub-effects:

(i) The increase in the consumer surplus ΔCR from entry.

(ii) The expected loss incurred by the entrepreneur $(\pi_E - pF) < 0$ for $p > p^R$.

(iii) The reduction in profits for the incumbent $(\pi_I^M - \pi_I^D)$ due to entry.

At this point, the welfare effects of entry are ambiguous: an optimistic entrepreneur increases the consumer rent in the market and reduces the profits of the incumbent. The entrepreneur incurs a loss because the expected profits of entry are negative. We can then state the following result:

Proposition 4 *In situations of uncertainty ($\delta > 0$) and optimistic entrepreneurs ($\alpha > \overline{\alpha}$), the expected total surplus is at least as high in the economy with optimistic entrepreneurs as in the economy with expected profit-maximizing entrepreneurs if and only if $\Delta CR \geq -(\pi_E - pF) + (\pi_I^M - \pi_I^D)$.*

Proof. See the Appendix. ■

In the next section, we will use a parametric product market model to explicitly analyse the product market interaction between an optimistic entrepreneur and an expected profit-maximizing incumbent. We will show that in such a setting, a sufficiently optimistic entrepreneur can increase the profits in the product market above what an expected profit maximizer can achieve. This analysis will allow us to identify an interval of optimism where entrepreneurial entry will necessarily be welfare enhancing.

4 How optimistic entrepreneurs compete in the product market

The entrepreneur's attitude towards uncertainty may also affect his or her behaviour in the product market interaction. For example, we could imagine that the entrepreneur is uncertain about the market size, the intensity of product market competition or her cost structure after entry. Here, we analyse the case in which the entrepreneur is uncertain about her own costs after entry.

This analysis corresponds to a situation in which an entrepreneur enters a market with a new, untested technology or a situation in which the entrant needs to hire new key employees, perhaps from the incumbent, in order to reach low costs. In such a case, there might not yet be a unique cost distribution, so uncertainty would prevail – at least for a while. We analyse this question in isolation from the predation threat emphasized in the previous setup, which allows us to illustrate the mechanisms in a simple setup.

To this end, we use a model of oligopolistic competition in which firms compete in quantities (Cournot fashion). The demand for both players is given by

$$P = A - x_I - x_E.$$

Market size is measured by the parameter A, and the quantities produced in the market by the incumbent I and the entrepreneur E are given by x_I and x_E, respectively. The entrepreneur and the incumbent face marginal costs c_E and c_I, respectively. We assume that the marginal costs c_E of the entrepreneur are described by a unique probability distribution with support on $[c_E^{low}, c_E^{high}]$ and mean $\overline{c_E}$. To avoid corner solutions, we assume $A + c_{j \neq i} - 2c_i > 0$ with $i \in \{E, I\}$, which ensures that each player will always want to play a positive quantity in equilibrium.

We first solve for the Nash equilibrium in this market under the assumption that both players will be expected profit maximizers. We will use the superscript R in relation to the incumbent's quantity and profit to indicate that they arise in the presence of an expected profit-maximizing entrepreneur. The reaction functions in this game are given by

$$x_I^R(x_E^R) = \frac{A - x_E^R - c_I}{2}, \qquad x_E^R(x_I^R) = \frac{A - x_I^R - \overline{c_E}}{2}. \tag{4}$$

The unique Nash equilibrium in this game is found in the intersection of both curves. The reaction functions correspond to the solid lines I and R in Figure 4. Solving for these functions yields the following equilibrium quantities and profits:

$$\begin{array}{ll} x_E^R = \frac{A-2\overline{c_E}+c_I}{3} & x_I^R = \frac{A-2c_I+\overline{c_E}}{3} \\ \tilde{\pi}_E^R = \pi_E^R = \left(\frac{A-2\overline{c_E}+c_I}{3}\right)^2 & \pi_I^R = \left(\frac{A-2c_I+\overline{c_E}}{3}\right)^2. \end{array}$$

Let us now turn to the entrepreneur who is uncertain about structural parameters that directly influence her behaviour in the product market. As above, we assume that the entrepreneur's best guess of the marginal cost distribution has a mean $\overline{c_E}$ and support on $[c_E^{low}, c_E^{high}]$, but now, there is some uncertainty around this with $\delta_C > 0$. We assume that the incumbent knows the entrepreneur's beliefs about the cost structure of the new technology ($\overline{c_E}$, c_E^{low}, c_E^{high} and δ_C). We assume the uncertainty around the cost structure δ_C to be unrelated to the uncertainty around the probability of meeting a tough opponent δ; this assumption allows us to analyse the two problems independently.

An uncertainty-sensitive entrepreneur maximizes the following objective function in product market competition:[14]

$$\tilde{\pi}_E^O(x_I, x_E) = \delta_C[\alpha\pi_E(x_I, x_E; c_E^{low}) + (1-\alpha)\pi_E(x_I, x_E; c_E^{high})] + (1-\delta_C)\pi_E(x_E, x_I; \overline{c_E}).$$

A priori, this expression looks like a vastly more complicated function than that for the expected profit maximizer; however, we can simplify the goal function due to the linearity in profits in our setup, as shown in the following lemma:

[14]Eichberger et al. (2008a) analyse a similar Cournot model but assume that both players are uncertainty sensitive and uncertainty manifests itself over the players' strategy choices.

Lemma 2 *The entrepreneur's objective function can be rewritten as*

$$\tilde{\pi}_E^O(x_I, x_E) = (A - x_I - x_E - \widetilde{c}_E)\, x_E$$
$$\textit{where: } \widetilde{c}_E = \delta_C[\alpha c_E^{low} + (1-\alpha) c_E^{high}] + (1-\delta_C)\overline{c_E}.$$

Proof. See the Appendix. ■

The uncertainty-sensitive entrepreneur thus maximizes an objective function that is virtually identical in form to that of the expected profit maximizer, except for the perception of marginal costs $\widetilde{c}_E$. To see how this situation affects optimal behaviour, we can again derive the reaction functions. We now use superscript O for both players to indicate that the expressions arise in the presence of an uncertainty-sensitive entrepreneur. The reaction functions are given by

$$x_I^O(x_E^O) = \frac{A - x_E^O - c_I}{2}, \qquad x_E^O(x_I) = \frac{A - x_I^O - \widetilde{c}_E}{2}. \tag{5}$$

When we compare these expressions to the reaction functions under risk (4), we see that the only difference lies in the cost perception $\widetilde{c}_E$, which will affect the intercept of the curve but not its slope. Higher or lower cost perceptions will thus shift the reaction curve inwards or outwards. In particular, if the cost perceptions are below the expected costs, the uncertainty-sensitive entrepreneur will play more optimistically than the expected profit maximizer, i.e., for every quantity the incumbent plays, the uncertainty-sensitive entrepreneur always plays a higher quantity than the expected profit maximizer.

Proposition 5 *If there is uncertainty $\delta_C > 0$ in the product market, the uncertainty-sensitive entrepreneur will play more optimistically than an expected profit maximizer if and only if $\alpha > \frac{c_E^{high} - \overline{c_E}}{c_E^{high} - c_E^{low}} \equiv \overline{\alpha_C}$.*

Proof. *Solving $\widetilde{c}_E < \bar{c}$ for α yields $\alpha > \frac{c_E^{high} - \overline{c_E}}{c_E^{high} - c_E^{low}}$.* ■

The condition ensures that the perceived costs are below the mean costs. Since more uncertainty will put more emphasis on the former, it will shift the reaction curve further out under this condition. Otherwise, more uncertainty would have the opposite effect. A higher α unambiguously decreases cost perceptions in the presence of uncertainty since $\frac{d\widetilde{c_E}}{d\alpha} < 0$ if $\delta_C > 0$.

[Figure 4 here]

We illustrate this situation graphically in Figure 4. Lines I and R are the incumbent's and the expected profit maximizer's reaction functions, respectively. Line O shows the reaction function of an uncertainty-sensitive entrepreneur with $\alpha > \frac{c^{high} - \bar{c}}{c_E^{high} - c^{low}}$. Since $\widetilde{c_E} < \overline{c_E}$ under these conditions, the reaction curve is shifted outwards. As δ_C and α increase, this shift becomes stronger. Under risk, the equilibrium in the product market was at point a, the intersection of I and R. The new equilibrium under uncertainty will be given by the intersection of I and O at point b. Compared to equilibrium a, the entrepreneur plays a higher quantity and the incumbent reduces her quantity. Since the entrepreneur increases her quantity by more than the incumbent, the overall supply in the market also increases. By looking at the iso-profit curve for the entrepreneur through point a, we can see that the equilibrium point b lies in the profit-enhancing zone for the entrepreneur, but this is not necessarily always the case, and we will return to this point later in this section.

Because the incumbent reduces her quantity and the overall quantity in the market increases, her new equilibrium profits will unambiguously be lower than before. This situation is visualized since the new equilibrium point b always lies above the incumbent's iso-profit curve through the old equilibrium point a. By solving the system of reaction functions, we obtain the following equilibrium quantities and profits, which support the results of the graphical analysis.

Lemma 3 *The equilibrium quantities and the perceived profits with cost uncertainty are given by*

$$x_E^O = \frac{A - 2\widetilde{c}_E + c_I}{3} \qquad x_I^O = \frac{A - 2c_I + \widetilde{c}_E}{3}$$
$$\tilde{\pi}_E^O = \left(\frac{A - 2\widetilde{c}_E + c_I}{3}\right)^2 \quad \pi_I^O = \left(\frac{A - 2c_I + \widetilde{c}_E}{3}\right)^2.$$

Proof. Solve the equation system of reaction curves (5) and plug the resulting equilibrium quantities into the (perceived) profit expressions. ■

From the equilibrium quantities, we see that the entrepreneur's perceived profits increase with a lower cost perception $\widetilde{c_E}$. However, in general, the entrepreneur's perceived profits will not coincide with her expected profits. Moreover, since the entrepreneur's behaviour in the product market is affected by her uncertainty attitude and the amount of uncertainty she perceives, her expected profits will also no longer coincide with the expected profits of a standard agent. We next turn to the analysis of this issue.

We again make a number of simplifying assumptions in our analysis. In particular, we rely on the notion that uncertainty and the entrepreneur's uncertainty attitude are common knowledge. In principle, it is possible to allow the incumbent to be unsure about the exact value of both parameters. If the incumbent expects a more aggressive play from the entrepreneur, our results would still follow.

4.1 How some but not too much optimism improves profits and welfare

Plugging the equilibrium quantities under uncertainty into the entrepreneur's profit function yields the following expression:

$$\pi_E^O = \underbrace{\left(\frac{A - 2c_E + c_I}{3}\right)^2}_{\pi_E^R} + \underbrace{\frac{(\bar{c}_E - \widetilde{c}_E)(A + 2\widetilde{c}_E + c_I - 4\overline{c_E}))}{9}}_{\Delta_E^O}.$$

We rearrange the expression to highlight the gap that uncertainty drives between realized profits of the uncertainty sensitive entrepreneur and the expected profit maximizer. Clearly, if there were no uncertainty, Δ_E^O would be zero and we would again have the standard model. If $\widetilde{c}_E > \overline{c_E}$, an uncertainty-sensitive entrepreneur will act pessimistically. For every quantity the incumbent plays, the uncertainty-sensitive entrepreneur plays a lower quantity than the expected profit maximizer to insure herself against the worst possible outcome. In that case, her profit will be unambiguously smaller than that for an expected profit maximizer because, given the regularity conditions, the first term in Δ_E^O would be negative and the second term would be positive in order to ensure positive equilibrium quantities ($A+c_I-2\overline{c_E}>0$). In the opposite case, however, there is scope for the uncertainty-sensitive entrepreneur to achieve a higher profit than an expected profit maximizer. We summarize this situation in the following proposition:

Proposition 6 *For a given market structure A, c_I, c_E and uncertainty level $\delta_C > 0$, the following statements hold:*

1. An uncertainty-sensitive entrepreneur earns an expected profit that is at least as high as that of an expected profit maximizer ($\Delta_E^O \geq 0$) if and only if $\alpha \in [\overline{\alpha_C}, \overline{\alpha_H}]$.

2. For all other levels of α, an uncertainty-sensitive entrepreneur will earn a lower profit than an expected profit maximizer ($\Delta_E^O < 0$).

Proof. *See the Appendix.* ■

To illustrate this result, we plot π_E^O as a function of α in Figure 5. For very low α, the entrepreneur's reaction curve is to the left of the expected profit maximizer's reaction curve, and her equilibrium profits will be lower than for an expected profit maximizer. Increasing α will gradually shift her reaction curve outwards – essentially implying that the equilibrium point moves up on the incumbent's reaction function curve.

This situation has two effects: first, the incumbent reacts to the entrepreneur playing a higher quantity by decreasing her quantity played, resulting in a higher market share for the entrepreneur, which, keeping prices fixed, increases her profits. Second, because the entrepreneur extends her quantity by more than the amount the incumbent reduces hers, the overall quantity in the market increases and prices decrease. Margins also decrease, exerting a negative effect on profits. The balance of these two effects allows the profits to initially increase, as long as the quantity effect dominates the price effect, and then decrease as soon as the price effects begin to dominate the quantity effect.

[Figure 5 here]

Knowing that the expected profits of an uncertainty-affine entrepreneur can be above those of an expected profit maximizer opens up the possibility that the entry of uncertainty-sensitive entrepreneurs must not necessarily be excessive. Rather, because the entrepreneur has a positive attitude towards uncertainty, she can credibly commit to a more optimistic plan of action in the product market competition game. This credible bolder plan of action will lead the incumbent to react more timidly and thus allow the uncertainty-sensitive entrepreneur to gather a larger market share than the expected profit maximizer can get. This larger market share allows the uncertainty-sensitive entrepreneur to profitably enter markets that expected profit maximizers cannot enter.

Proposition 7 *There exist markets in which an uncertainty-sensitive entrepreneur can and will profitably enter* $\pi_E^O - pF \geq 0$ *and* $\tilde{\pi}_E \geq 0$*, but an expected utility maximizer* $\pi_E^R - pF \leq 0$ *cannot profitably enter.*

Proof. *See the Appendix.* ■

Having established the above, we can now analyse the welfare effects of optimistic entrepreneurs in such markets. The difference in welfare induced by an optimistic entrepreneur and an expected profit maximizer for positive uncertainty levels is given by

$$\Delta W = W^O - W^R = \begin{cases} \pi_E^O + \pi_I^O + \Delta CR^O - (\pi_E^R + \pi_I^R + \Delta CR^R) & \text{if } p \in [0, p^R] \\ \pi_E^O - pF - (\pi_I^M - \pi_I^O) + \Delta CR^O & \text{if } p \in]p^R, p^O[\\ 0 & \text{otherwise.} \end{cases}$$

We can then derive the following result:

Proposition 8 *If the uncertainty sensitive entrepreneur is optimistic enough to enter the market* ($\alpha > \overline{\alpha}$) *and the deterrence costs are not too large* ($pF < \max_\alpha \pi_E^O(\alpha)$)*, then there exists a convex, non-empty set of uncertainty attitudes* $A \subset [0, 1]$ *such that for each* $\alpha \in A$*, the expected welfare in the economy with uncertainty-sensitive entrepreneurs is at least as high as the expected welfare of profit-maximizing entrepreneurs.*

Proof. *See the Appendix.* ■

The proposition tells us that if optimistic entry occurs and the deterrence costs are not excessive – that is, the entrepreneur's level of optimism is above some threshold α for which the perceived profits are larger than zero and the deterrence costs are such that profitable entry is conceptually possible – then there exists an interval of optimism for which entry will be beneficial not only for consumers but also for the entrepreneur herself. Because entrepreneurs who are optimistic but not too optimistic can create the most profitable ventures, they can also enhance welfare in a society.

We have assumed product market interaction in terms of strategic substitutes. Alternatively, we can think of product market interactions using strategic complements.[15] An optimistic entrepreneur's reaction curve shifts inwards in a price diagram; she will perceive lower costs, which will induce her to set the prices more aggressively, i.e., closer to her actual marginal costs. The incumbent would react to such an entrepreneur by, in turn, also lowering her prices. The resulting equilibrium under optimism would be one with lower profits, lower consumer prices, and higher consumer rent.

5 Conclusions

We have provided novel empirical evidence that uncertainty (rather than risk) and optimism are distinctive aspects of young, high-impact entrepreneurial firms (recently listed firms) relative to old incumbent firms. We also referred to evidence suggesting that high-impact entrepreneurial firms are typically opposed by established incumbents but that entrepreneurs are typically prone to resisting such strategic uncertainty.

Based on this evidence, we have constructed an entrepreneurial entry predation model with uncertainty. We show that entrepreneurial optimism can serve an important role against strong incumbents' attempts to protect markets using predatory threats. Moreover, entrepreneurial optimism can also create a strategic advantage for entrepreneurs since incumbents may react by being less aggressive in the product market interaction, which will benefit not only the profitability of the entrepreneur's venture but also con-

[15] Eichberger et al. (2008b) solve a model with imperfect price competition and two firms being ambiguous about the opponent's strategy choices.

sumers via lower prices. Thus, entrepreneurial optimism seems important in times of high uncertainty, such as during technology shifts or large deregulation programs.

This paper has important implications for both entrepreneurs and incumbents. First, optimistic entrepreneurs may have an incentive to reveal their optimism in order to credibly commit to being a strong player in the market in the future. For example, they may begin small-scale entry into local markets, working with intermediaries that specialize in marketing and distribution, and introduce their products into some retailers' assortments; in these activities, they show proof of optimism. These entrepreneurs may also seek support from angels or venture capitalists and use their experience to verify the optimism in their venture. Another way to signal their optimism might be repeated entrepreneurship. Rather than a learning device as suggested in Parker (2013), serial entrepreneurship might be a signaling device. Incumbents, on the other hand, have an incentive to try to resist the entrepreneur's optimistic strategy as long as the uncertainty decreases and the entrepreneur becomes less optimistic. In particular, in the early phase of the entrepreneur's venture, incumbents may try to be very reactive and reveal information about market conditions in order to remove some of the uncertainty in the market.

This paper also points to several implications for governmental policy. First, it suggests that large-scale investment in costly informational campaigns with the purpose of reducing entrepreneurial optimism regarding its business opportunities might be counterproductive. The positive externalities of optimism identified in this paper might then be hampered. Second, the findings in this paper suggest that policy design might be more involved than otherwise thought. For instance, tax policies that do not change the expected return on entrepreneurship might in fact still change the incentive to undertake entrepreneurship. If optimism is in play, increasing taxes on high-income states and reducing them on low-income states can actually reduce entrepreneurial activities even though the expected tax payment from a risk perspective would not change.

Our model also has several limitations. The theoretical result that entrepreneurial optimism may have strategic positive effects for consumers and the entrepreneur does not hold if the oligopolistic effects are small. Our results will then vanish since the externalities on consumers and incumbents are small. However, in practice, many markets that entrepreneurs enter are oligopolistic. We have also abstracted from possibilities for entrepreneurs and incumbents to signal preferred types. Extending the analysis along these lines seems to be an interesting avenue for future research.

In our model, we have focused on the beneficial effects of optimism to defuse deterrence threats and thereby benefit everyone. However, optimism can also make it easier for incumbents to deter entry. For example, if the incumbent were also optimistic, the profits that the entrepreneur could achieve in the market would decrease. An interesting question for further research is thus whether optimism can also be beneficial to society in a wider context.

Additionally, an interesting avenue for research would be to test our proposed model of creative destruction under uncertainty in relation to the classical model of creative destruction under risk. As discussed above, changes in tax policy might be useful in this context. Tax policies will affect expected profits of entrepreneurship differently from its effect on the best and worst outcomes. According to the creative destruction model under risk, a tax reform that does not affect expected tax payments but improves the best outcome and worsens the worst outcome would not affect entrepreneurial activity; in contrast, it should increase entrepreneurial activity under our proposed creative destruction model under uncertainty.

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6 Tables and Figures

Table 1: Summary statistics, Compustat 1995-2015 excl financials and utilities

	Unit	N	Mean	S.D.	p5	p50	p95
Uncertainty/Risk	Ratio	54810	2.01	1.25	0.412	1.83	4.24
Uncertainty Share	%	54810	0.56	0.28	0.150	0.550	1.04
Risk Share	%	54810	0.34	0.17	0.13	0.31	0.64
Forward Tone	Ratio	54810	1.16	1.59	0.18	0.75	3.50
Age	Years	54810	16.20	16.00	1.21	11.38	46.37
log(Age)	Log	54810	2.33	1.06	0.00	2.48	3.85
Total Q	Ratio	54810	1.59	3.47	-0.14	0.76	5.54

Table 2: The relationship of risk, ambiguity and tone to age

	Uncertainty/Risk	Uncertainty Share	Risk Share	Tone
log(*Age*)	-0.139***	-0.119***	0.0224***	-0.0943***
	(0.0124)	(0.00995)	(0.00449)	(0.0208)
Total Q	0.0139*	0.0127**	-0.000242	0.0288**
	(0.00744)	(0.00511)	(0.00202)	(0.0122)
Observations	54,810	54,810	54,810	54,810
R^2	0.185	0.465	0.252	0.074
Number of Firsm	7,757	7,757	7,757	7,757
FE	Year Firm	Year Firm	Year Firm	Year Firm
Cluster	Firm	Firm	Firm	Firm

Age is the time between the company first appeared in CRSP and the filing of the current annual report. *Uncertainty/Risk* is the ratio of the number of ambiguity terms to risk terms in the business description section of annual reports. *Uncertainty Share* and *Risk Share* are the shares of ambiguity and risk terms in the same section. *Tone* is the ratio of positive to negative terms in forward-looking statements of the MD&A. All outcome variables are standardized. Standard errors are clustered at the firm level.

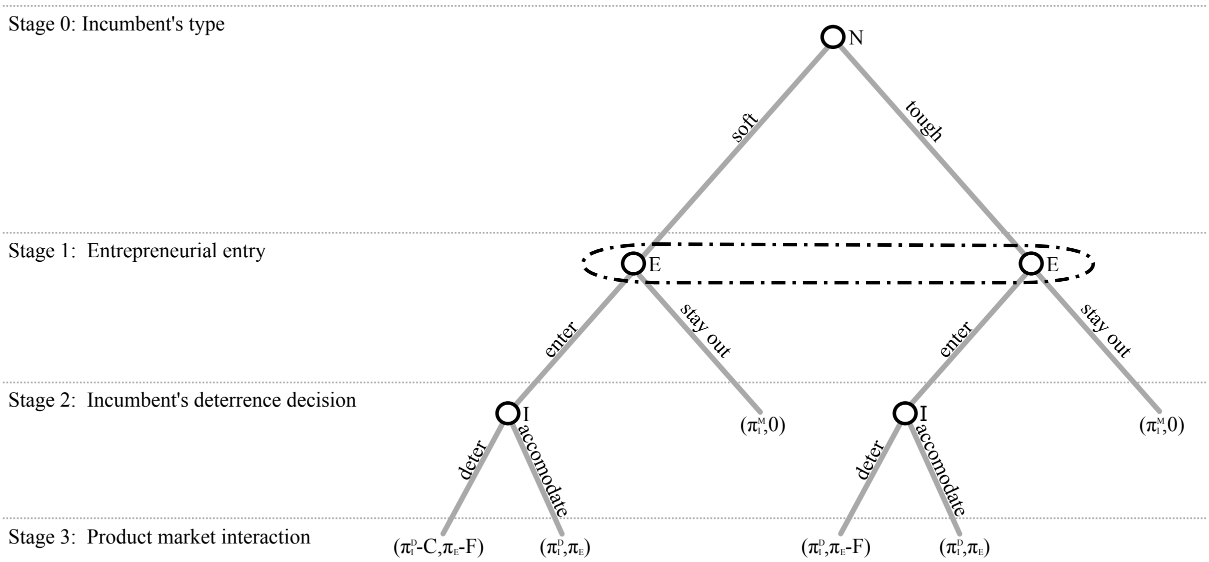

Figure 2: Game tree of our base model. Payouts are in monetary terms, which corresponds to utility of the expected profit maximizer, but not necessarily to the utility of the uncertainty sensitive type.

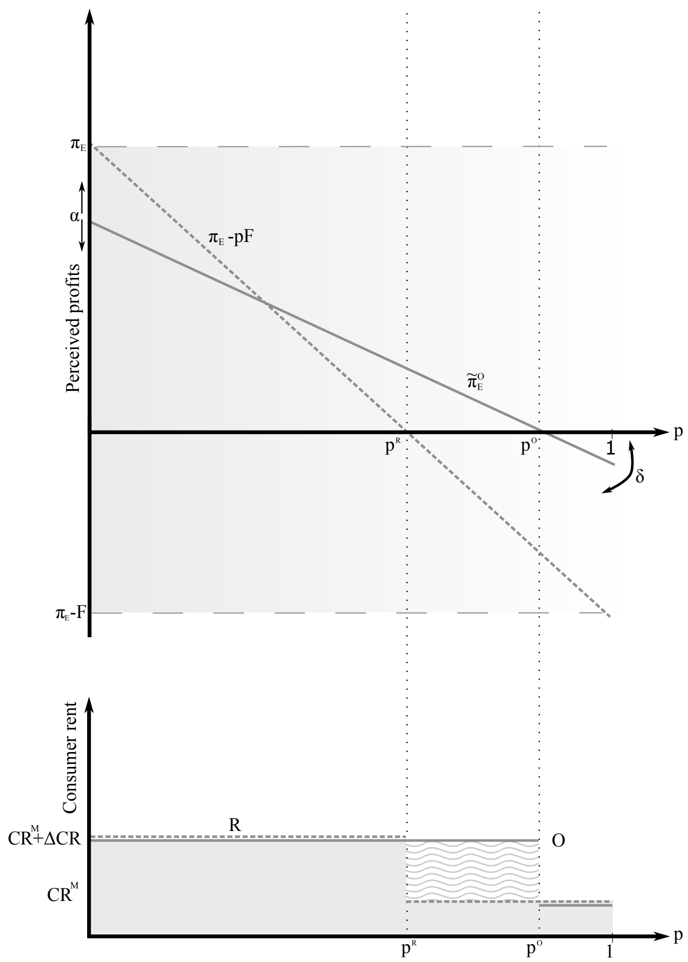

Figure 3: The upper graph shows the entry conditions of an uncertainty sensitive entrepreneur and an expected profit maximizer and how they vary with different parameter setups. The dashed grey line shows the expected (and perceived) profits of an expected profit maximizer. The solid grey line shows $\tilde{\pi}_E^O$ for an $\alpha > 1 - \pi_E/F$. Increasing or decreasing α would shift the line upwards or downwards, while increasing or decreasing δ would make the curve flatter or steeper. The extreme cases of maximum uncertainty with maximum optimism or pessimism are given by the horizontal lines at π_E and $\pi_E - F$. The lower graph illustrates the difference in expected consumer rents between uncertainty sensitive and regular agents for cases with $\delta > 0$ and $\alpha > 1 - \pi_E/F$. The curly area between p^R and p^O marks cases where the optimistic entrepreneur creates higher consumer rent than the expected profit maximizer.

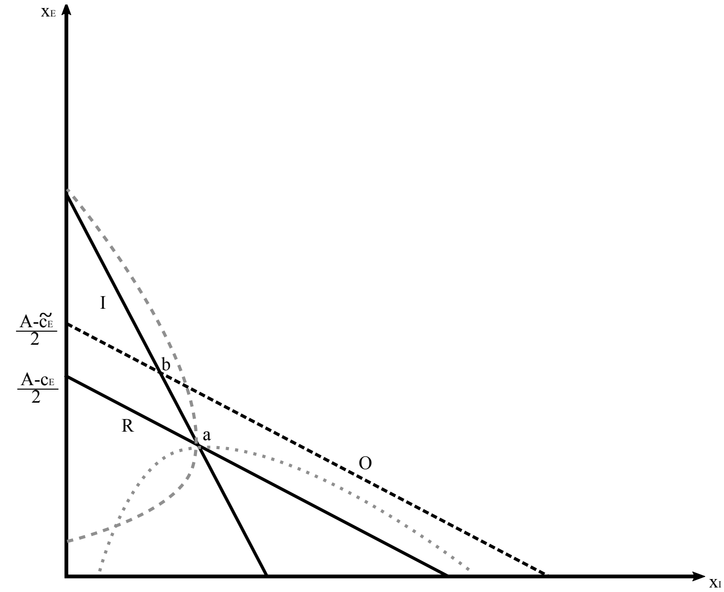

Figure 4: Lines R and I show the reaction curves with an expected profit maximizing entrepreneur and incumbent, respectively. Curve O shows the reaction curve of an uncertainty sensitive agent with a large $\alpha > \bar{\alpha_C}$. Equilibrium quantities are found in the intersection of the reaction curves at points a and b. The light-grey dashed and dotted curves represent iso-profit curves for the entrepreneur and the incumbent, respectively.

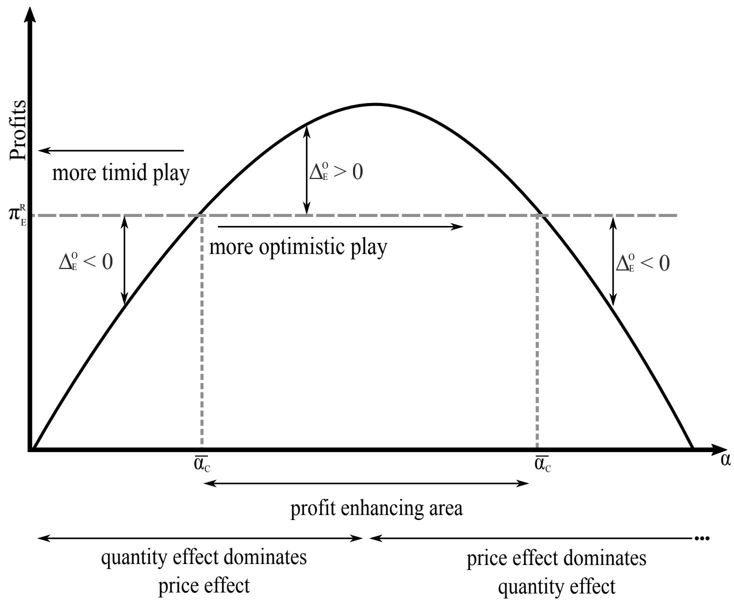

Figure 5: The real expected profits of the entrepreneur. At $\bar{\alpha_C} = \frac{c_E^{max}-c_E}{c_E^{max}-c_E^{min}}$, the profits correspond to those of an expected profit maximizer. Due to strategic externalities, the expected profit maximizer is not actually in a profit maximum – she is constrained by the reaction function of the incumbent. More timid play lets us wander to the left of the profit curve – this can never be profit increasing, as both the quantity and price effects are negative. More aggressive play is initially profit increasing, reaches a maximum for some α and then declines again until it turns negative at $\bar{\alpha_H}$. The graph shows that more aggressive play cannot just increase the perceived profits, but also the actual profits of an uncertainty sensitive entrepreneur.

7 Appendix

7.1 Proof Proposition 1

We start with the extreme cases: with no uncertainty, $\delta = 0$, there is no behavioral difference between R and O since $\widetilde{\pi}_E^O = \pi_E^R$. For extreme uncertainty, $\delta = 1$, $\widetilde{\pi}_E^O = \pi_E > 0$ and $\widetilde{\pi}_E^O \geq \pi_E^R$ for all p – the uncertainty sensitive type would thus always enter, even for levels of p that deter the expected profit maximizer. For all intermediate cases, $\delta \in]0, 1[$, we can make the following graphical argument using Figure 5. A non-zero δ makes the perceived profit curve unambiguously flatter; increasing α increases the intercept of the perceive profit curve, but leaves the slope unchanged. In particular, for $\alpha = 1$ and $\delta > 0$, the intercepts of the curves coincide, while the perceived profit curve is flatter than the expected profit curve. It will thus intersect the x-axis after the expected profit curve, which proves our proposition. Algebraically, we can solve $\widetilde{\pi}_E^O(p) = 0$ and $\pi_E^R(p) = 0$ for p and set the resulting expressions equal. Some algebra reveals that the curves intersect the x-axis at the same point if $\pi_E - (1 - \alpha)F = 0$. Hence, for $1 - \frac{\pi_E}{F} < \alpha \leq 1$ our statement holds. □

7.2 Proof Lemma 1

Set $\pi_E^R = 0$ and $\widetilde{\pi}_E^O = 0$ and solve for $p^O(\alpha)$ and p^R. This yields $p^O(\alpha) = \frac{\delta(\alpha\pi_E^{max} + (1-\alpha)\pi_E^{min})}{(1-\delta)F} + \frac{\pi_E}{F}$ and $p^R = \frac{\pi_E}{F}$. Equating the two expressions and solving for $\overline{\alpha}$, the uncertainty level δ drops out and we are left with the cutoff condition $\overline{\alpha} = -\frac{\pi_E^{min}}{\pi_E^{max} - \pi_E^{min}}$. □

7.3 Proof Proposition 2

If payoff uncertainty is resolved, we have $\pi_E^{\max} = \pi_E^{\min} = \pi_E^O = \pi_E^R$ and hence $\pi_E^R = \widetilde{\pi}_E^O$. The two entrepreneurial types will then behave identically. Payoff uncertainty is resolved when the incumbent's deterrence decision is observed either at the initial entry decision or at the exit option. Further, if there is an exit option, then all relevant downside risk is eliminated at the initial entry decision. The expected profits at the time of the entry decision are: $\pi_E^R(enter) = (1-p)\cdot\pi_E + p\cdot 0 > 0 = \pi_E^R(stayout)$. The perceived profits of the uncertainty sensitive agent at this point are: $\widetilde{\pi}_E^O(enter) = \delta[\alpha\pi_E + (1-\alpha)\cdot 0] + (1-\delta)[(1-p)\pi_E + p\cdot 0] > 0$. Both entrepreneurial types will thus initially enter and then react in the same way to the actions of the incumbent. Note that the converse of the statement is not true, because behavior could also be identical for some α and δ.$\square$

7.4 Proof Proposition 3

If $\delta = 1$, the optimistic entrepreneur always enters and $E(CR^O) = CR^M + \Delta CR \geq E(CR^R)$. If $\delta \in]0,1[$, we have $1 \geq p^O > p^R = \frac{\pi_E}{F}$ by Lemma 1, our assumption $\alpha > \overline{\alpha}$ and $\pi_E - F < 0$. For $[0, p^R]$ both would enter and for $[p^O, 1]$ none would enter: the expected consumer rent would be identical. Since $]p^R, p^O[\neq \varnothing$, there exist situations where only the optimistic type enters in which case, $E(CR^O) - E(CR^R) = \Delta CR > 0$. The result also holds for the special case of no uncertainty where there would once more be no behavioral differences between the types and $E(CR^O) = E(CR^R)$. $\square$

7.5 Proof Proposition 4

If $\delta = 1$, the optimistic entrepreneur always enters. In the interval $[p^R, 1]$, the expected profit maximizer would not enter; on this interval $\Delta W \geq 0$ if and only if the above condition holds. If $\delta \in]0,1[$, we have $1 \geq p^O > p^R = \frac{\pi_E}{F}$ by Lemma 1, our assumption $\alpha > \overline{\alpha}$ and $\pi_E - F < 0$. For $[0, p^R]$ both would enter and for $[p^O, 1]$ none would enter: the expected welfare is thus identical. Since $]p^R, p^O[\neq \varnothing$, there exist situations where only the optimistic type enters in which case $\Delta W \geq 0$ if and only if the above condition holds. Note that this result does not hold for $\delta = 0$: since the behavior between the entrepreneurial types would not differ, welfare would be identical, irrespective of the above condition. $\square$

7.6 Proof Lemma 2

With a slight abuse of notation, we can write profits in the best, worst and expected case as: $\pi_E^j = (A - x_I - x_E - c^j)x_E$. for $c^j \in \{c^{low}, c^{high}, \overline{c_E}\}$. We can thus split profits in each case into a common part that is the same across cases and an idiosyncratic part that is case specific: $\pi_E^j = (A - x_I - x_E)x_E - c^j x_E$. This allows us to collect terms across cases and write: $\tilde{\pi}_E^O(x_I, x_E) = (A - x_I - x_E)x_E - [\delta_C \alpha c_E^{low} + \delta_C(1-\alpha)c_E^{high} + (1-\delta_C)\overline{c_E}]x_E$. Now define $\widetilde{c}_E \equiv \delta_C[\alpha c_E^{low} + (1-\alpha)c_E^{high}] + (1-\delta_C)\overline{c_E}$. This allows us to write $\tilde{\pi}_E^O(x_I, x_E) = (A - x_I - x_E - \widetilde{c}_E)\, x_E$. □

7.7 Proof Proposition 6

Excess profits are given by $\Delta_E^O = \frac{(\bar{c}_E - \widetilde{c}_E(\alpha))(A + 2\widetilde{c}_E(\alpha) + c_I - 4\overline{c_E}))}{9}$ where $\widetilde{c}_E(\alpha) = \delta_C[\alpha c_E^{low} + (1-\alpha)c_E^{high}] + (1-\delta_C)\overline{c_E}$. They are thus additive and quadratic in α. The second derivative is strictly negative $\frac{\partial^2 \Delta_E^O}{\partial \alpha^2} = -4\delta_C^2(c_H - c_L)^2 < 0$ – the excess profits are thus strictly concave in α. Next, we identify the points at which the excess profits are zero: we solve $\Delta_E^O(\alpha) = 0$. This equation has two solutions at $\overline{c_E} - \widetilde{c_E}(\alpha_1) = 0$ and $A + c_I - 4\overline{c_E} + 2\widetilde{c_E}(\alpha_2) = 0$ with $\alpha_1 = \frac{c_E^{high} - \overline{c_E}}{c_E^{high} - c_E^{low}}$ and $\alpha_2 = \frac{A - 2\delta_C \overline{c_E} - 2\overline{c_E} + \overline{c_I} + 2\delta_C c_E^{high}}{2\delta_C(c_E^{high} - c_E^{low})} = \frac{A - 2\overline{c_E} + \overline{c_I} + 2\delta_C(c_E^{high} - \overline{c_E})}{2\delta_C(c_E^{high} - c_E^{low})} = \alpha_1 + \frac{A - 2\overline{c_E} + \overline{c_I}}{2\delta_C(c_E^{high} - c_E^{low})}$. Given our regularity assumption $A + c_I - 2\overline{c_E} > 0$, we get $\alpha_2 > \alpha_1 > 0$. We note that $\alpha_1 = \overline{\alpha_C}$, which is the cutoff condition for a more optimistic play from Proposition 5. We set $\overline{\alpha_H} \equiv \alpha_2$. To prove the first part of our proposition: we note that $\frac{\partial \Delta_E^O(\alpha_1)}{\partial \alpha} = \frac{\delta_C(c_E^{high} - c_E^{low})(A - 2\overline{c_E} + \overline{c_I})}{9} > 0$. Slightly increasing α from the level $\overline{\alpha_C}$ thus increases the profits. Further, $\frac{\partial \Delta_E^O(\alpha_2)}{\partial \alpha} = -\frac{\delta_C(c_E^{high} - c_E^{low})(A - 2\overline{c_E} + \overline{c_I})}{9} < 0$. Slightly decreasing $\overline{\alpha_H}$ at α thus decreases the profits. Since Δ_E^O is strictly concave and the excess profits are zero at $\overline{\alpha_C}$ and $\overline{\alpha_H}$, we have shown that the excess profits are weakly positive on the interval $[\overline{\alpha_C}, \overline{\alpha_H}]$. Note that $\overline{\alpha_H} > 1$ is possible for very low δ_C in which case the upper bound of the interval will not be binding. The second part of the proposition is the flip-side of the first part and immediately follows. □

7.8 Proof Proposition 7

Proof by example. Assume that $\pi_E^R - pF = 0$, the expected profit maximizer would not want to enter the market. We want $\tilde{\pi}_E^O > 0$ and $\pi_E^O - pF > 0$. Pick $\alpha = 1$ and $\delta_1 = 0$. The profits will be the same as for the standard agent. Now slightly increase $\delta = \delta_1 + \varepsilon$.

From Proposition 5, we know that the profits will be larger for $\alpha \in [\overline{\alpha_C}, \overline{\alpha_H}]$. We note that $\lim_{\delta \to 0} \overline{\alpha_H} = \lim_{\delta \to 0} \alpha_1 + \frac{A - 2\overline{c_E} + \overline{c_I}}{2\delta_C (c_E^{high} - c_E^{low})} = \infty$. There thus exists $\varepsilon > 0$ for which any admissible level of $\alpha > \overline{\alpha_C}$ increases the profits. Picking such an ε with a large enough α ensures that $\pi_E^O - pF \geq 0$ – clearly $\alpha = 1$ would be large enough. To show that $\tilde{\pi}_E \geq 0$, we simply note that for $\alpha = 1$, only the best case is taken into account when making the entry decision for any non-zero uncertainty level. The best case is above zero, because the expected profits are also larger than zero. □

7.9 Proof Proposition 8

If the market structure is such that both entrepreneurial types would enter ($p \in [0, p^R]$), pick $A = [\overline{\alpha_C}, \overline{\alpha_H}] \cap [0, 1]$. By Proposition 6, for each $\alpha \in [\overline{\alpha_C}, \overline{\alpha_H}] = A$, the entrepreneur will do better than the expected profit maximizer ($\pi_E^O - \pi_E^R > 0$). The reduction in profits for the incumbent ($\pi_I^O - \pi_I^R < 0$) is offset by a larger change in consumer rent ($\Delta CR^O - \Delta CR^R$), because prices are closer to their competitive level and welfare goes up. If only the optimistic entrepreneur enters ($p \in [p^R, p^O]$) we define $A = [\overline{\alpha_{Low}}, \overline{\alpha_{High}}] \cap [0, 1]$ where $\overline{\alpha_{Low}}, \overline{\alpha_{High}}$ solves $\pi_E^O(\alpha) - pF = 0$. We know that $\pi_E^O(\alpha)$ is additive, quadratic and strictly concave in α ($\frac{\partial^2 \Delta_E^O}{\partial \alpha^2} < 0$). Hence $0 < \overline{\alpha_{Low}} < \overline{\alpha_{High}}$ exists. Since we have $pF < \max_{\alpha \in [0,1]} \pi_E(\alpha)$, we know that $A \neq \emptyset$. For $\alpha \in A$, we have $\pi_E^O - pF > 0$ because the deterrence costs are not excessive. For the remaining part, the same welfare results as before follow. □