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# Changing risks and optimal effort

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ABSTRACT

Consider a decision maker who can engage in effort to increase the probability of facing a better risky situation. Intuition suggests that effort should increase when there is a greater difference between the best risky situation and the worse one. We show that this intuition is not necessarily valid and we consider the cases of risk averters and risk lovers.



## 1. Introduction

Recently Jindapon and Neilson (2007) studied how much effort a decision maker should invest in order to benefit from an improvement in the risks he faces. In their paper this improvement takes the form of an *N*th-order reduction in risk à la Ekern (1980), a special case of *N*th-order stochastic dominance.

Quite interestingly a related question had been analyzed much earlier in Ehrlich and Becker (1972) but in a rather different context (and under the terminology of "self protection"). In Ehrlich and Becker the effort is made to obtain a specific first-order stochastic improvement that takes the form of a reduction in the probability of a given potential loss, the amount of which is non random.

In this paper we concentrate on "the missing part" and we analyze the effort invested to reduce the probability of facing a deteriorated risk in the sense of general first-order stochastic dominance (hereafter FSD). As a result our analysis is more general than that of Ehrlich and Becker, since here in the two states of nature (success or failure of the effort) final wealth will be random while in Ehrlich and Becker it is a fixed amount of money in each state.

Once the problem is defined, we focus on an issue which was neglected both in Jindapon and Neilson (2007) and in Ehrlich and Becker (1972): the case when one of the two risks changes. This is relevant since in the real world people make their choices in order to face "more favourable" risks in a context where all risks they may face change over time.[1] Moreover, as

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[1] Two examples on this kind of choices, related to health and to fire risks, are presented at the beginning of Section 4. Other similar examples can be easily proposed for the cases of safety in driving, burglary risk or the risk of travel accidents.

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Jindapon and Neilson (2007) generalize Ehrlich and Becker (1972), the analysis of different changes in one of the two risks potentially faced by the decision maker can be seen as a generalization of the comparative statics analysis in the case of non-random potential loss, studied in the literature by Sweeney and Beard (1992).[2]

We thus have the following question: what happens if one of the two risks either improves or deteriorates via FSD?[3] This case is particularly significant since when we assume that the "better risk" is replaced by a new one dominating it via FSD, we are somehow increasing the "distance" between the two risks in terms of FSD. Similarly, when we assume that the "worse risk" is replaced by a new one dominating it via FSD, the "distance" between the two risks in terms of FSD reduces and the two risks become more similar.

This reasoning would suggest a simple conjecture on a decision maker's (henceforth DM) reaction to the risk change: an FSD improvement on the better risk,[4] making the two risks "more different", should push the DM to increase effort. On the contrary, an FSD improvement on the worse risk, making the two risks "more similar", should push the DM to reduce his effort. Our analysis will show that this conjecture is correct only under some assumptions on DM preferences and that, in general, the effects of this kind of changes are complex and depend on the features of DM attitude toward risk.

An FSD change in one of the two risks is just one of the possible situations that the DM may cope with. In particular, an extension of this analysis can be easily obtained by assuming that one of the two risks experiences an $N$th-order risk change.[5] The analysis of this case will show the role of high-order derivatives of the utility function in determining DM choices.

It is worth noticing that the effects of changes in risks on effort are analyzed in other recent papers too. Eeckhoudt et al. (2012), Wang and Li (2015), Nocetti (2016) and Wang et al. (2015) examined the effects on effort of the introduction of a zero-mean background risk and of a deterioration in it. All these papers, however, examine two-period models (or equivalently models where the cost of effort is non-pecuniary) while the present work studies a one-period model (or equivalently a model where the cost of effort is pecuniary). As shown by the literature starting from Menegatti (2009), the results in these two frameworks may be largely different. Furthermore Eeckhoudt et al. (2012) and Wang and Li (2015) also assume that the changes in the background risk contemporaneously affect both the better risk and the worse risk, excluding the case where only one of the two risks changes.

Finally the closest analysis to that of our paper is presented by Chuang et al. (2013), who study changes in risks in a framework similar to ours. The present paper however generalizes that analysis in at least two directions. First, Chuang et al. (2013) limit their analysis to the case where the DM is risk averse while the present paper considers also the cases of risk neutrality and of risk loving. Second, we consider every possible change in the two risks faced by the DM (improvement in the better risk, worsening in the better risk, improvement in the worse risk, worsening in the worse risk) while Chuang et al. (2013) just study the cases where the distance between the two risks increases (improvement in the better risk and worsening in the better risk).

In this respect the present paper will extend the existing literature on effort in another direction. Indeed, although with some notably exceptions (quoted below), almost all papers in this field make the assumption that the DM is either risk averse or risk neutral.[6] However many experimental and empirical studies suggest that risk lovers represent a non negligible proportion of the population. For instance, the experimental works conducted by Noussair et al. (2013), Ebert and Wiesen (2014) and by Deck and Schelsinger (2014) highlight that the proportion of risk lovers in the population ranges from 15% to 20%. Depending on the type of activity considered, this proportion can even be larger. For instance, the empirical study made by Boussemart et al. (2015) indicates that more than 30% of French fattening pig farmers are risk lovers.

Since Jindapon (2013) has recently shown that risk lovers can engage into self protection (or "effort") as well as risk averters, we include their case in the analysis. In this regard, notice that Nocetti (2016) and Wang et al. (2015) derive their comparative statics results without introducing the assumption of risk aversion. However they do not discuss the different implications of the cases of risk aversion, risk neutrality and risk loving. This is a further difference between these papers and the present work.

Finally, for the analysis of $N$th-order risk changes, we will also refer to the concepts of "mixed risk aversion" (studied by Brockett and Golden, 1987 and Caballé and Pomansky, 1996) and of "mixed risk loving" (defined in Crainich et al., 2013). Eeckhoudt and Schlesinger (2006) have shown that mixed risk aversion is a generalization of the concept of risk aversion: while the latter indicates a preference for the disaggregation of sure losses, the former corresponds to the same preference when the DM is exposed to several harms taking the form of either sure losses or zero-mean risks. Likewise, the concept of mixed risk loving offers a generalization to that of risk loving since both refer to preference for the aggregation of goods.

[2] Besides Ehrlich and Becker (1972), Jindapon and Neilson (2007) and Sweeney and Beard (1992), other works are related to the present paper. First, in the self protection literature, Dionne and Eeckhoudt (1985), Briys and Schlesinger (1990), and Jullien et al. (1999) studied the role of risk aversion in the choice of effort level while Eeckhoudt and Gollier (2005), Menegatti (2009), Dionne and Li (2010) and Menegatti (2012) analyzed the role of prudence in it. All these papers, however, while dealing with the effects of different aspects of risk attitude on effort, did not examine the issue of changes in risks.

[3] Such a question is not discussed in Jindapon and Neilson who focus instead on the impact of preferences towards risk on the optimal level of effort.

[4] We will define more clearly this concept in Section 2.

[5] Notice the difference between this analysis and that by Jindapon and Neilson (2007). Jindapon and Neilson (2007) assume that the better risk is an $N$th-order reduction in the worse risk. In the present paper, instead, once assumed that the better risk dominates the worse risk, we study the effect of an $N$th-order change in one of the two risks.

[6] Notice that this is a further difference with Jindapon and Neilson (2007).