The Ultimate Approach to a New Concept.☆

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ABSTRACT

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KEYWORDS: Something Interesting, Risk Measures, Profoundly Irrelevant

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1 Introduction

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2 Some Math

Let $M, N : \tilde{\Omega} \times [0,T] \to \mathbb{R}$ be $(\tilde{\mathcal{F}}_t)$-adapted processes. The process M is called càdlàg, càglàd or làdlàg if the paths of M are càdlàg, càglàd or làdlàg quasi-surely, respectively. Given a làdlàg process, we denote by M^- and M^+ its càglàd and càdlàg version respectively, that is

$$M_t^- := \lim_{s \nearrow t} M_s, \quad \text{for } t \in]0,T], \quad \text{and} \quad M_0^- := M_0,$$
$$M_t^+ := \lim_{s \searrow t} M_s, \quad \text{for } t \in [0,T[, \quad \text{and} \quad M_T^+ := M_T,$$

outside the polar set where M is not làdlàg. Two $(\tilde{\mathcal{F}}_t)$-adapted processes $M, N : \tilde{\Omega} \times [0,T] \to \mathbb{R}$ are modifications of each others, if $M_t = N_t$, for all $t \in [0,T]$. We say that M is a *supermartingale* or a *strong supermartingale*, if $M(\theta)$ is a supermartingale or a strong supermartingale, for all $\theta \in \Theta$, respectively. See [**?** , Appendix I] for a definition of strong supermartingales.

Let us define the following sets of value and control processes:

- $\mathcal{S}$ is the set of $(\mathcal{F}_t)$-adapted làdlàg processes $Y : \Omega \times [0,T] \to \mathbb{R}$;
- $\tilde{\mathcal{S}}$ is the set of làdlàg processes $Y : \tilde{\Omega} \times [0,T] \to \mathbb{R}$, which have a modification $\hat{Y}$ satisfying $\hat{Y}_t \in C(\tilde{\mathcal{F}}_t) \cap L^1_b(\tilde{\mathcal{F}}_t)$, for all $t \in [0,T]$, and such that $Y(\theta)$ is optional, for all $\theta \in \Theta$.
- For any $\theta \in \Theta$, let $\mathcal{L}(\theta)$ be the set of $(\mathcal{F}_t)$-predictable processes $Z : \Omega \times [0,T] \to \mathbb{R}^d$ such that $P\left[\int_0^T \|Z_u \theta_u^{1/2}\|^2 du < \infty\right] = 1$.
- $\tilde{\mathcal{L}}$ is the set of $(\tilde{\mathcal{F}}_t)$-predictable processes $Z : \tilde{\Omega} \times [0,T] \to \mathbb{R}^d$ such that $Z(\theta) \in \mathcal{L}(\theta)$, for all $\theta \in \Theta$.

A *generator* is a jointly measurable function g from $\tilde{\Omega} \times [0,T] \times \mathbb{R} \times \mathbb{R}^{1\times d}$ to $\mathbb{R} \cup \{+\infty\}$ such that the mapping $(s, \omega, \theta) \mapsto g_s(\omega, \theta, y, z) : ([0,t] \times \tilde{\Omega}, \mathcal{B}([0,t]) \otimes \tilde{\mathcal{F}}_t) \to (\mathbb{R}^d, \mathcal{B}(\mathbb{R}^d))$ is measurable, for each t, for all $(y,z) \in \mathbb{R}^{d+1}$. We say that a generator g is

(POS) positive, if $g(\theta, y, z) \geq 0$;

(LSC) if $(y,z) \mapsto g(\theta,y,z)$ is lower semicontinuous;

(MON) increasing, if $g(\theta,y,z) \geq g(\theta,y',z)$, whenever $y \geq y'$;

(MON′) decreasing, if $g(\theta,y,z) \leq g(\theta,y',z)$, whenever $y \geq y'$;

(CON) convex, if $g(\theta,y,\lambda z+(1-\lambda)z') \leq \lambda g(\theta,y,z)+(1-\lambda)g(\theta,y,z')$, for all $\lambda \in (0,1)$;

(NOR) normalized, if $g(\theta,y,0)=0$;

$P \otimes dt$-almost surely, for all $y,y' \in \mathbb{R}$, all $z,z' \in \mathbb{R}^{1\times d}$ and all $\theta \in \Theta$.

A pair $(Y,Z) \in \tilde{\mathcal{S}} \times \tilde{\mathcal{L}}$ is said to be a *supersolution* of the BSDE with generator g and terminal condition $\xi \in L^0(\tilde{\mathcal{F}}_T)$, if

$$Y_\sigma(\theta) - \int_\sigma^\tau g_u(\theta, Y_u(\theta), Z_u(\theta))du + \int_\sigma^\tau Z_u(\theta)d\tilde{W}_u(\theta) \geq Y_\tau(\theta) \quad \text{and} \quad Y_T(\theta) \geq \xi(\theta), \tag{2.1}$$

for all $\sigma,\tau \in \mathcal{T}$, with $\sigma \leq \tau$, and for all $\theta \in \Theta$. For such a supersolution (Y,Z), we call Y the *value process* and Z its *control process*. In order to exclude doubling strategies we only consider control processes, which are admissible, that is $\int Z(\theta)d\tilde{W}(\theta)$ is a supermartingale, for all $\theta \in \Theta$. We denote the set of such supersolutions by

$$\mathcal{A}(\xi,g) = \{(Y,Z) \in \tilde{\mathcal{S}} \times \tilde{\mathcal{L}} : Z \text{ is admissible and } (\textbf{??}) \text{ holds}\}. \tag{2.2}$$

A pair (Y,Z) is said to be a *minimal supersolution*, if $(Y,Z) \in \mathcal{A}(\xi,g)$, and if for any other supersolution $(Y',Z') \in \mathcal{A}(\xi,g)$, holds $Y_t \leq Y'_t$, for all $t \in [0,T]$. The natural candidate for the value process of a minimal supersolution is the infimum, that is

$$\hat{\mathcal{E}}_t(\xi) := \hat{\mathcal{E}}_t^g(\xi) := \inf\{Y_t : (Y,Z) \in \mathcal{A}(\xi,g)\}, \quad t \in [0,T]. \tag{2.3}$$

The goal is to find a modification $\mathcal{E}(\xi)$ of $\hat{\mathcal{E}}(\xi)$ that belongs to $\tilde{\mathcal{S}}$ and some admissible process Z in $\tilde{\mathcal{L}}$ such that $(\mathcal{E}(\xi),Z)$ fulfills (**??**), that is $(\mathcal{E}(\xi),Z)$ is a minimal supersolution.

3 Conclusion

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