



# EXPECTED PRESENT VALUE OF TOTAL DIVIDENDS IN THE COMPOUND BINOMIAL MODEL WITH DELAYED CLAIMS AND RANDOM INCOME\*

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**Abstract** In this paper, a compound binomial model with a constant dividend barrier and random income is considered. Two types of individual claims, main claims and by-claims, are defined, where every by-claim is induced by the main claim and may be delayed for one time period with a certain probability. The premium income is assumed to another binomial process to capture the uncertainty of the customer's arrivals and payments. A system of difference equations with certain boundary conditions for the expected present value of total dividend payments prior to ruin is derived and solved. Explicit results are obtained when the claim sizes are  $K_n$  distributed or the claim size distributions have finite support. Numerical results are also provided to illustrate the impact of the delay of by-claims on the expected present value of dividends.

**Key words** compound binomial model; main claim; by-claim; dividend; random income

**2010 MR Subject Classification** 60J27; 60J28; 62P05; 60K39

## 1 Introduction

In recent years, insurance claims may be delayed due to various reasons. Since the work by Waters and Papatriandafylou [1], risk models with this special feature have been discussed by many authors in the literature. Indeed, a frame work of delayed claims is built by introducing two kinds of individual claims, namely main claims and by-claims, and allowing possible delays

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of the occurrences of by-claims. A significant amount of work has been done in this area. See, for example, Yuen and Guo [2], Yuen et al. [3], Xiao and Guo [4], Xie and Zou [5], etc.

Dividend strategy for insurance risk models were first proposed by De Finetti [6] to reflect more realistically the surplus cash flows in an insurance portfolio, and he found that the optimal strategy must be a barrier strategy. From then on, barrier strategies have been studied in a number of papers and books. Claramunt et al. [7] calculated the expected present value of dividends in a discrete time risk model with a barrier dividend strategy. Other risk model involving dividend payments were studied by Gerber and Shiu [8], Zhou and Guo [9], Fang and Wu [10], Wu and Li [11] and the references therein.

All risk models described in the paragraph above relied in the assumption that the premium is collected with a positive deterministic constant rate. Thus, if no other investment income is taken into account, the insurer's income will be proportional to the time interval. However, it is evident that the deterministic premium income fails to capture the uncertainty of the customers' arrivals. To reflect the cash flows of the insurance company more realistically, in recent years, risk models with random income have been one of the major interests in the risk theory literature. Bao and Liu [12] studied a compound binomial risk model with delayed claims and random income. Recursive equations for both the probability of ultimate ruin and the joint distribution of the surplus one period prior to ruin and the deficit at ruin were obtained. Dong et al. [13] calculated the Gerber-Shiu function in a risk process with random income and a constant barrier. Related works can be found in Bao [14], Bao and Ye [15], Yang and Zhang [16] and the references therein.

The model proposed in this paper is a generalization of compound binomial risk model with paying dividends and delayed claims. It seems to be the first risk model with delayed claims, a constant dividend barrier and random income. We show that, the explicit expression for the expected present value of total dividends in this risk model can be obtained. The work of this paper can be seen as a complement to the work of Bao and Liu [12] that calculated the expected present value of total dividends in the compound binomial model with delayed claims and random income. The model considered in this paper is also related to the one considered by Wu and Li [11]. Although both models employ a discrete time risk model with dividends and delayed claims, our model differs from the one by Wu and Li [11] as follows. Our model is more general than that of Wu and Li [11] in that we assume the premium income process is a binomial process with a certain parameter, while the premium is a positive deterministic constant in Wu and Li [11].

The rest of this paper is organized as follows. Section 2 defines the model of this paper, describes various payments, including the premiums, claims and dividends, and lists the notation. In Section 3, difference equations with certain boundary conditions are developed for the expected present value of total dividend payments prior to ruin. Then an explicit expression is derived, using the technique of generating functions. In Section 4, closed-form solutions for the expected present value of dividends are obtained for two classes of claim size distributions. Numerical examples are also provided to illustrate the impact of the delay of by-claims on the expected present value of dividends in Section 4.

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