Referee Report on

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Ex-Ante Regulation and Ex-Post Liability under Uncertainty and Irreversibility:
Governing the Coexistence of GM Crops

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This paper provides an adequate and timely treatment of several important questions that surround the debate on GM crops. It makes contribution to the existing literature by highlighting several key arguments. Firstly, it reiterates the important fact that uncertainty and irreversibility have an effect on the optimal decision of a farmer whether or not to adopt a GM crop. While switching to GM crops may initially seem like a great idea, it may become much less attractive once the effects of uncertainty and irreversibility are considered. In addition to this, the authors present a novel insight that ex-ante regulations (usually in the form of a separation, or minimum distance requirement) and ex-post liability have a similar effect: they reduce the attractiveness of GM farming. This is done by introducing a jump diffusion process (sometimes referred to as a mixed Ito-Jump process) to represent the payoff from adopting a GM crop. While this is a rather elegant and appropriate approach, the readers would benefit from greater explanation about the drivers of the diffusion process. The uncertainty behind the Poisson process used to model the ex-post liability is intuitive: it is driven by the probability of causing harm to non-GM farmer, the probability of establishing liability through the legal system, and the probability of recovering the awarded compensation from the liable party. More intuition should be offered as a rationale for using a diffusion process to model the uncertainty and irreversibility.

Secondly, the contribution is made by giving prominence to the spatial distribution of the adoption of GM crops, and by examining how the ex-ante regulation and ex-post liability may affect the pattern of spatial distribution. It is found that the ex-ante regulation may asymmetrically affect farmers, based on the size of their farms. In particular, stringent minimum distance requirements imposed on GM adopting farmers may prevent small farmers from adoption due to prohibitively high opportunity cost of the land dedicated to separate the GM and the neighbouring non-GM farm. In this situation, it is likely that no coexistence will develop, resulting with a 'corner' solution whereby either all farms in a region will adopt GM, or all farms will remain non-GM. It seems that this finding, which no doubt has to be further formalised and refined, would have a strong practical implications for regions where smaller-scale farming is dominant, such as parts of Southern Europe, as well as substantial parts of East and South-East Asia. In addition, the issues of required coordination, cooperation, or purely self motivated behaviour leading to a socially optimal outcome at a spatial scale emerge in this 'all or nothing' scenario.

Even when the size of farms is not a binding factor under presence of ex-ante regulation, the spatial dispersion of GM adopters is an intriguing question. How fast is a GM crop likely to be adopted within a particular region, or landscape? What are the other factors that may influence this spatial pattern? It seems that future work in this

direction should include intertemporal modelling, where sequential decisions about adopting GM or not by individual farmers can be modelled based on their interactions with GM and non-GM neighbours who in turn take into account ex-ante regulation and ex-post liability in making their own decision. This can then be used to determine a spatio-temporal equilibrium: a situation where there will be no conversion from non-GM to GM, or vice versa, from one time period to the next.

Besides making these important contributions, the paper opens up a number of questions that will no doubt be a focus of the future work in this area. One of those questions is: are ex-ante regulations needed in the presence of enforceable ex-post liability? This question really boils down to the long standing debate on Pigouvian (more geared towards ex-ante regulation) versus Coasian (geared towards ex-post liability) paradigms. An additional question that this paper opens up is: what is the 'optimal mix' of ex-post regulation and ex-post liability given the various legal systems, implying various 'easiness of suing the GM farmer'. In jurisdictions where there is joint and several and strict liability, there seem to be little justification for ex-ante regulation, whereas in jurisdictions where Civil Law doctrine guides the determination of ex-post liability, the ex-ante regulation may be required. Finally on this point, the question of endogenously determined ex-ante minimum distance requirement emerges, even if it is not directly discussed in the paper. Endogenously determined minimum distance requirement in the presence of ex-post liability means that the GM famer can decide on their own about the optimal separation distance between them and the non-GM farmer. The coexistence in this case can be achieved either by ex-ante separation or by ex-post compensation for damages caused. In theory, the GM farmer should be indifferent between the two, and should choose one, the other, or a combination of the two, based on the principle of cost-effectiveness.

In all, the paper offers substantial contribution and insight in some key issues that are likely to be a focus of the future work in this dynamic research area. The paper is well written, enjoyable and easy to read and understand. I recommend it to the readers of the Journal.