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Golden Rice: no progress to be seen. Do we still need it?

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ABSTRACT. In the December 2014 issue of *Environment and Development Economics*, we published the article, 'The economic power of the Golden Rice opposition' by Wesseler and Zilberman. The paper generated substantial interest, not only in academia but also among civil society groups. In this note, we address some of the concerns that have been raised about our results. Our main conclusion remains that misguided regulations in the case of Golden Rice have cost millions of healthy life years and billions of dollars.

In the December 2014 issue of this journal we published the article, 'The economic power of the Golden Rice opposition' (Wesseler and Zilberman, 2014). The paper generated substantial interest, not only in academia but also among civil society groups. Since its publication, the paper has become the most downloaded paper in *Environment and Development Economics*. The paper has an Altmetric (2016) score of 392, which measures the wider social impacts of publication, and is among the top 5 per cent of all papers published and in the 99th percentile of publications of the same vintage. Responses in some social media outlets have been rather critical.

Let us first summarize the paper, which applies the real option approach to develop a methodology to assess the monetary cost of delaying the permission to introduce a technology in order to resolve some of the uncertainty about the technology's social impact. It applies the model to compute the expected cost of delay of the introduction of Golden Rice in India. We computed both the annual expected costs and accumulative cost, both in dollars and disability-adjusted life years. These costs are very high (billions of dollars and millions of disability-adjusted life years) and raise the

question as to whether the option value of the extra caution that was behind the regulation is worth the cost of the delay.

In this note, we address two main concerns that have been raised about the paper. First, we assumed that Golden Rice would have been available for utilization in 2002, but it has not yet been commercialized (e.g. Stone, 2015; Philpott, 2016). We used 2002 as the starting point based on the expectations by experienced rice breeders and experts in genetic engineering (Enserink, 2008). However, the regulatory system delayed the introduction of the technology, and these delays are discussed in detail by Potrykus (2010), Dubock (2014) and Stone (2015). In 2005, Bradford *et al.* (2005: 442) warned about the drawbacks of the regulation, saying:

> Release of Golden Rice awaits deregulation of a single event and backcrossing into locally adapted varieties, rather than simultaneously transforming the required genes into a range of varieties. Thus, restrictive event-specific regulatory policies act to reduce biological diversity by forcing backcrossing of single events rather than use of diverse genetic backgrounds.

The probability of success would have been higher if, instead of a sequential approach, a parallel approach had been used, thereby accelerating the process, but this would have been very costly due to regulation (Dubock, 2014) – an issue that is not only relevant for Golden Rice, but for genetically modified (GM) crops in general (Strauss and Sax, 2016).

An important related point is that our analysis was applied to India, where the severity of Vitamin A deficiency is likely to be the greatest and where no solution is close to fruition. The technology is not considered in India due to heavy domestic opposition, despite the country's significant indigenous capacity in plant breeding and agricultural biotechnology. Furthermore, India recently rejected the introduction of GM eggplant (Herring, 2014).

The second concern raised is that 'Golden Rice' is not needed because alternative solutions exist that could address the problem (e.g., Philpott, 2016). The claim that our argument is weakened by the availability of alternative approaches to the Vitamin A deficiency issue is in fact discussed in our paper. We pointed out that if affordable alternatives exist worldwide, then Golden Rice is unnecessary. But despite reducing Vitamin A deficiency in parts of the world, such as the Philippines, there are still important parts of the world where it prevails, namely in South Asia and Sub-Saharan Africa (Stevens *et al.*, 2015). This is the reason why our option value calculation was based on the Indian case study where we anticipated that the problem would last longer. But even if Vitamin A deficiency can be reduced using alternative means, the alternatives can be expected to be expensive, and Golden Rice can be an important cost-effective part of the solution (Stein *et al.*, 2008).

In summary, the main contribution of our paper is to introduce a methodology to compute the option value of delay in the introduction of a technology. We used Golden Rice as a numerical example to illustrate the concept and generate some real-world insights. There is clear evidence that the introduction of Golden Rice is delayed by regulation, and

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in India this is mainly induced by opposition to the technology. If there is a sense of urgency to save healthy life-years of individuals who suffer from Vitamin A deficiency, parallel testing of multiple events should be done. Furthermore, regulatory frameworks can be streamlined to accelerate finding the solution to various diseases. Golden Rice is a 'medical application' for the millions of sufferers in India (and elsewhere). The required time frame of testing can be shortened (Chaturvedi *et al.*, 2012). Our main conclusion remains that misguided regulations in the case of Golden Rice have cost millions of healthy life-years and billions of dollars, a claim that has recently been supported by more than 100 Nobel Prize Laureates (Achenbach, 2016).

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