Referee's Report on
**"Minimum Quality Standards and Novelty Requirements in s
One-shot Development Race"**,
by Jacek Prokop, Pierre Regibeau and Katharine Rockett

The paper investigates the effect of minimum quality standards and novelty requirements on the timing of the introduction of new products into a market with potentially up to two competitors. For this purpose the authors consider a deterministic R&D stopping game where the two firms increase the quality of their new product in a totally predetermined way as long as they do not introduce it to the market. After the product is introduced the quality can no longer be changed. As long as one firm is alone on the market it serves a Hotelling market as a monopolist. After the other firm has also introduced its product the first firm is either pre-empted and substituted by the other firm located at the other end of the market with a necessarily higher quality product or competes against the other firm depending on the quality difference which corresponds to the different timing between the two firms. The latter is pretty much in the spirit of Riordan (1992) who investigated the adoption of a new technology by two firms and the change in the timing of this adoption if price and entry regulations prevail in the market.

The authors first consider a symmetric situation where both firms achieve the same quality improvements by waiting. They show that there are always two subgame perfect equilibria where one firm enters first and is followed later by the other firm. Depending on the level of quality improvement by waiting another unit of time compared to the level of horizontal product differentiation and the discount factor the leading firm can choose its optimal timing taking into account the time it takes the follower to enter the market or, if the improvement is too high, it needs to speed up its own entry in order not to be leap-frogged by the other firm. If waiting is even more productive in terms of quality improvements the follower is going to substitute the leader in the market and will have a monopoly position in that market after entry.

For a given entry date of the leader the follower either enters too early from a social welfare point of view if the follower is not going to substitute the leader but competes with him after entry or he is entering too late if he can gain a monopoly position after its entry. The leader enters too early for all those parameters where he can choose its optimal pattern of timing (with a low productivity of waiting) or those where the follower is going to substitute him (for a relatively high productivity of waiting). For intermediate levels of the productivity of waiting where the leader needs to speed up the process more than he would actually like it but where the leader is not out-competed

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after the entry of the follower, the leader enters too late from a social welfare perspective.

Introducing a minimum quality standard into the symmetric market always forces the leader to wait longer and can change the character of the equilibrium from being one in which the leader needed to speed up its product introduction towards one where he does not need to do so. Overall social welfare is improved in all those cases where the leader entered too early and for some of the ones where he entered too late and the productivity of waiting is relatively high.

Introducing a novelty requirement into the symmetric market forces the follower to wait longer until it can enter the market. It improves welfare in all those cases where the follower entered too early and the leader chooses his optimal quality level. It decreases social welfare in all those cases where the follower enters too late anyhow (if he substitutes the leader). In the intermediate cases of the productivity of waiting, both the follower and the leader lose profits but due to the early initial entry in the market the overall welfare effect might still be positive.

Finally the authors consider the asymmetric case where the productivity of waiting is different between the two firms. They conclude from their analysis that it depends on the parameters of the model whether the low productivity firm or the high productivity firm enters first. With minimum quality standards it is possible to reverse the order of entry between the low productivity and the high productivity firm in all those cases where the low productivity firm enters first. Whether this also increases the overall social welfare depends on the effect the minimum quality standard has on the entry time of the follower.

Although investigating the timing of product innovation is not really a brand new topic in the research on innovations (see e.g. Hoppe and Lehmann-Grube (2005)) the authors manage to get something new out of it when analyzing the effect of minimum quality standards and stronger novelty requirements on the timing of innovations. Nevertheless the authors can still improve a lot on the current analysis.

1. The authors do not get too much out of the asymmetric case. Given Riordan's result it is not really surprising that the low productivity firm can enter first. Proposition 6 does, however, not clarify for which sets of parameters this is going to happen or whether this equilibrium is unique or not. Unfortunately the proof for this proposition is also close to undigestible. From my point of view the authors have two options:

- Either they clearly improve and become more specific about the asymmetric case and much clearer in the proof of the then modified proposition 6,

- or they drop the asymmetric case.

2. In general it is a good idea to collect all the formal proofs in an Appendix. It is, however, still necessary to present them in a concise and structured way. Here the Appendix is a huge mess of different approaches and lots of redundancies. In addition it does not always become clear which argument actually proves which proposition. The appendix needs streamlining. Given that the authors keep the asymmetric case in the paper, it would clearly make sense to start the analysis with the asymmetric case and push it as far as possible. Then it should be simple to consider the symmetric case and derive some additional results.

3. What happens in this model depends on the parameter θ/r, the productivity of waiting relative to the discount factor, compared to the level of product differentiation in the Hotelling model c, the linear "transport costs". The latter determines how tough the firms compete after the second firm has entered the market. However the authors never really discuss c or r. Therefore they could as well set $c = r = 1$. This way they should be able to simplify the analysis and presentation of all the different cases.

4. Due to the totally deterministic model higher quality can only be achieved by delaying entry. In reality the quality can be increased by pouring more R&D resources into the process without necessarily delaying the time of entry. At some point the authors should discuss whether costs of delayed entry/product innovation act in the same way as the costs of pouring more R&D resources into the process.