# Commercialization Mechanisms for New Plant Varieties

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**Abstract** Developing and marketing new varieties is essential for the long-term profitability of US crop producers. The ultimate goal of university breeding programs is to release improved plant varieties, either with superior quality or more efficient production management. For certain horticultural products, notably apples, plant breeders have developed several new differentiated varieties that have the capacity to be marketed with premium prices and that can compete on world markets. If these innovations are not commercialized or are commercialized in a suboptimal way, then the benefits of the research are greatly reduced. In this chapter, we use game theoretic analysis and an experimental auction to investigate the effects of contract exclusivity and payment structure on innovator and producer profits from a hypothetical new apple variety.

## Introduction

Developing and marketing new varieties is essential for the long-term profitability of US crop producers. Responding to this need, there has been a rapid increase in the number of patented fruit varieties released by university breeding programs (Brown and Maloney 2009; Bareuther 2011; Gallardo et al. 2012). The ultimate goal of these programs is to release improved plant varieties, either with superior quality or more efficient production management. For some grain and oilseed crops, we have observed a number of new varieties that aim to reduce per acre costs through improvements in yields. There are many examples of new specialty crop

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varieties that were developed specifically to increase quality, some of which command a large premium in the market. For certain horticultural products, notably apples, plant breeders have developed several new differentiated varieties that have the capacity to be marketed with premium prices and that can compete on world markets. Once these new varieties are developed, they must be commercialized. If the innovations are not commercialized or commercialized in a suboptimal way, then the benefits of the research are greatly reduced.

Federal and state support for research and development (R&D) at public universities had been down over the last few decades prior to 2010 (Alston et al. 2010). This general trend has also been occurring for horticultural crops (Cahoon 2007; Alston and Pardey 2008), but it has been moderated to some degree by the introduction of new federal funding (e.g., the Specialty Crop Research Initiative) that began in 2008. Decreasing government support creates strong incentives to develop alternative ways to fund R&D activities at public universities (Huffman and Just 1999; Just and Huffman 2009), including the use of intellectual property rights (IPRs) and patents for innovations introduced by public universities, made possible by the passage of the Bayh-Dole Act in 1980. The Bayh-Dole Act gave universities the ability to claim IPRs for federally funded, university-conducted research, where the revenue flows from the patents are used to support the universities' R&D efforts. However, the use of patents by universities and the subsequent licensing issues raise questions about the best mechanism for funding research investments and maximizing industry revenues.

The traditional arguments for public funding of research are that knowledge spillovers and imperfect IPR protection cause innovators to not realize the economic value of their discoveries, leading to private sector underinvestment in basic research. Public land grant universities are a special case of government funding of academic research. The US land grant mission of research and extension faculty is to deliver and apply research and new knowledge to positively impact communities. US land grant university agricultural research is funded in many ways, sometimes including mandatory assessments on growers. In the case of mandatory assessments, growers have paid a portion of the R&D costs and thus expect to benefit from the research. In the case of new varieties introduced by public universities, there are many economic issues to resolve in order to maximize the long-run revenues to the overall industry and to universities' research programs. An open research question is then, given the political and funding constraints surrounding the development of new fruit varieties, what is the optimal way to commercialize publically developed innovations?

## Commercialization Mechanisms of University Innovations

There are several factors to consider in a commercialization process. One factor is the exclusivity of the commercialization. The question is whether all growers should have access to innovations that are developed at public universities, often accomplished with funds from mandatory grower assessments. The University of Minnesota has developed licensing schemes wherein a cooperative of growers is able to obtain exclusive access to a variety – a "managed variety" – for a fee that is levied both on the initial planting (a fixed fee) and percentage of sales on every box sold thereafter (a per-unit royalty). This approach is extremely controversial; other states are committed to providing the industry with equal access to new crop varieties for all growers or providing access through a lottery that allocates trees. Indeed, growers who were denied full access to a patented apple variety released by the University of Minnesota instigated legal action (see Lehnert 2010; Milkovich 2011). As a result of this litigation, administrators at other land grant universities are reluctant to employ exclusive contracts. Cornell University introduced two patented apple varieties in 2015 and made them available to all growers in New York State; they also levied a two-part fee on both the trees (a fixed fee) and the fruit that was marketed each year (a per-unit royalty). In terms of the economics, if the innovation results in product differentiation, then market power can exist. If the innovator limits the quantity made available to growers, the selected growers will receive a higher price in the market. Alternatively, if all growers have unlimited access, it will drive the final product price down.

A second factor is the structure of the contracts. Proprietary innovations, whether in agriculture or elsewhere, are utilized under licenses issued by the innovator, which are typically paid for using either fixed fees or per-unit royalties, where the total royalty payment depends on the number of units used. New institutional arrangements have arisen for the transfer of new plant varieties from research universities to consortia or cooperatives of growers willing to pay for licenses for new varieties (Cahoon 2007), but pricing mechanisms in these markets have been inefficient and not conducive to the rapid growth of R&D in new fruit varieties.

Licensing mechanisms for patented fruit varieties are typically established via negotiations between a technology transfer office (TTO) and grower-based licensees. These negotiations typically begin with a request for bids from potential licensees. The bids are evaluated based on financial and management considerations by the TTO with a focus on initial payments, annual payments, quality control issues, contracts with individual growers, and marketing plans. A successful bid for a new variety may allow the licensee the first right of refusal on subsequent varietal introductions. The licensees may include growers or grower-packers, a grower-owned cooperative, or a management company acting on behalf of a group of growers.

In practice, varieties are licensed to individual growers and the licensing mechanisms involve some combination of upfront fixed fees and output royalties that require annual payments based on the quantity of fruit that is marketed. In the case of perennial fruit crops, we consider the upfront fees to include the one-time charges applied per unit of land or per tree. Ad valorem or per-unit output royalties have not been widely used for patented fruit varieties but are becoming more common (Brown and Maloney 2009).

Previous literature has explored innovator profits under fees and royalty schemes. In particular, Arrow (1962) showed that it is profit-maximizing if the innovator is perfectly competitive. In the context of imperfect competition, Kamien and Tauman

(1986), Katz and Shapiro (1986), and Kamien et al. (1992), studying oligopolistic innovators, showed that a fixed fee generates higher revenue for an innovator (new entrant) than a royalty scheme. In contrast, royalties, or a combination of fees and royalties, have been found to yield the greatest profits for innovators in empirical applications (Sen and Taumann 2007).

In order to reconcile theoretical predictions with real-life observations, subsequent research has incorporated more realistic institutional settings and characteristics in modeling frameworks, including product differentiation (Muto 1993; Fauli-Oller and Sandonis 2002), risk aversion (Bousquet et al. 1998), asymmetric information (Gallini and Wright 1990; Sen 2005), moral hazard (Choi 2001), strategic delegation (Saracho 2002), and incumbency (Shapiro 1985; Kamien and Tauman 2002; Sen and Tauman 2007), among others. Such detailed characterization of various attributes of market stakeholders and interactions allowed the researchers to reconcile theory with empirical evidence. A key distinguishing feature of all of these studies, however, is that they primarily focus on cost-reducing innovation, which is certainly of interest to some industries. However, for the horticultural industry, the interest primarily lies in quality-improving innovation rather than cost-reducing.

Li and Wang (2010) examine the profits an inventor can realize by using an exclusive or a nonexclusive contract (under different licensing schemes). They focus on a vertical quality innovation, which is the type of innovation that describes new fruit varieties with better eating qualities. Their nonexclusive case has two licensees. They show that, in the case of a duopoly, licensing by means of a two-part tariff (i.e., a combination of fixed fee and per-unit royalty) generates greater profits for the innovator compared to licenses that are financed through royalties or fees alone. By setting the license price such that both downstream firms license an improved product, the licensee is able to raise industry profit and then extract much of the resulting surplus via a fixed fee. Rickard et al. (2016) examine the fee-versus-royalty decision with more than two potential licensees; they collect data from an experiment that captures many of the important conditions facing fruit growers considering an investment in patented varieties. Their results suggest that the profits for the innovator (the university in this case) will be maximized with the use of royalties on the annual production of fruit in a nonexclusive contract when a new variety is introduced. We argue that the innovator has multiple objectives and multiple licensees. Specifically, the innovator wishes to maximize the weighted sum of its own revenues and the licensees' revenues. We consider a range of weights assigned to the innovator and hence the producers, to provide a more complete understanding of how the licensing decision will affect the joint economic outcome. This scenario corresponds to the case of a US land grant university (the innovator) and its stakeholder growers (the licensees). We discuss results from experimental auctions with apple growers and simulations.

## Evaluation of Commercialization Mechanisms

### *Theory of Innovation, Licensing, and Market Competition*

This section makes an argument based on the theoretical model developed in Akhundjanov et al. (2017). In particular, the model is designed to examine contracts for an innovator who owns a patent for a new technology and whose objective is to maximize the weighted sum of its own profits and the licensees' profits. This objective is consistent with the mission of US land grant universities, which is to provide research in agricultural and related sciences that is designed to improve information and technologies for US producers. In this context, the land grant university is the innovator and the growers are the licensees. This is different from previous literature where the innovator only cares about its own profits.

In order to study, the effect of market competition on profits, we do not limit the number of firms in the market ex ante. Firms are assumed to produce a homogenous product, with constant unit production costs, and compete in the market as Cournot oligopolists. The innovation introduced by the innovator is vertical, meaning that a new technology enables licensees to produce a better quality product (i.e., a vertically differentiated product) than those produced using the old technology. Thus, the firms must decide whether or not to compete for the acquisition of an IPR for such new technology. Consumers are assumed to have Mussa and Rosen (1978) type of utility, which depends on the quality level of a product and the product market price. We model the quality of a product as a function of the degree of vertical product innovation (i.e., the level of quality improvement), which allows us to explore the impact of quality improvement on market demand, and consequently the returns to firms and the innovator.

We examine the innovator and firm profits under different licensing arrangements using a game theoretic framework, by first analyzing the innovator's decision problem (i.e., the licensing decision), then the problem of the firm(s) that adopt a new technology, and finally the remaining firms in the industry that continue using old technology. We consider three types of licensing contracts through which the innovator can release its innovation: a fixed fee, a per-box royalty, and a two-part tariff, which is essentially the combination of fixed fee and per-box royalty. These contracts come in two forms: exclusive or nonexclusive contracts. Further, we set the weighting parameters such that the innovator places equal weights on its own and the licensees' profits.

The results from numerical simulations indicate that, under an exclusive contract, the innovator generates the greatest profits with the two-part tariff, followed by the fixed fee and then the per-box royalty. On the other hand, with nonexclusive contract, the innovator's profits are the greatest with the two-part tariff, followed by the per-box royalty and then the fixed fee. Moreover, the innovator's profits are largely unaffected by the industry size under exclusive contracts, while the profits become sensitive to the size of the industry under nonexclusive contracts, which makes an intuitive sense. In general, from the innovator's perspective, a nonexclusive contract with either a two-part tariff or a per-box royalty, depending on the level of innovation, is always preferred. The two-part tariff dominates other commercialization mechanisms at higher levels of innovation, while the per-box royalty contract is dominant at relatively lower levels of innovation.

The analysis of the firm (the licensee) profits demonstrates that, under exclusive contracts, the firm receives the greatest profits with the per-unit royalty, followed by the fixed fee and then the two-part tariff. In contrast, with nonexclusive contracts, the firm's profits are the largest with the fixed fee, which holds true across different industry structures and levels of innovation, followed by the per-box royalty and then the two-part tariff. However, if the level of innovation is low and/or the industry size is large, then the profit-ranking under nonexclusive contract becomes the fixed fee, followed by the two-part tariff and then the per-box royalty. Overall, from the firm's (the licensee's) perspective, an exclusive contract with per-box royalty is beneficial. Since US land grant universities emphasize a broad impact of their research and extension work, then focusing more on nonexclusive licensing arrangements in the analysis would be more appropriate. The predictions from the theoretical model are tested with data that we collected in an experiment, and we will discuss the details in the following section.

## *Experiments with Washington Apple Growers*

In order to understand firm (licensee) preferences for different commercialization mechanisms, and also to evaluate innovator and licensee profits under these schemes, we conducted experimental auctions with Washington apple growers during the Washington State Horticultural Association Annual Meeting in December 2014. In particular, we had 32 apple growers participating in the experiment, who collectively operated 26,080 acres (or 16% of all apple acreage in Washington) and had on average 23 years of experience in apple production. See Akhundjanov et al. (2017) for the details of the experiment and other statistics.

We conducted Becker-DeGroot-Marschak (BDM) auctions (Becker et al. 1964), where the participants bid on hypothetical access to growing a promising new apple variety using licensing schemes distinguished by contract type (fixed fee, per-box royalty, and two-part tariff) and the degree of contract exclusivity (exclusive and nonexclusive). The participants submitted a bid to obtain access to grow 1450 trees, which is the conventional number of trees that can be grown on one acre of land. The experiment was designed to closely mimic the actual situation that growers find themselves in while deciding whether or not to adopt a new fruit variety.

Figure 1 provides the distribution of all growers' bids (in $) under different licensing arrangements. It is apparent that the growers in general are willing to pay more under fixed fee, per-box royalty, and two-part tariff (combination) when the contract is exclusive. This makes an intuitive sense as the grower who is able to have a sole access to an IPR is also willing to pay an extra premium for it. Further, since a two-part tariff combines both fixed fee and per-box royalty in a single contract, we

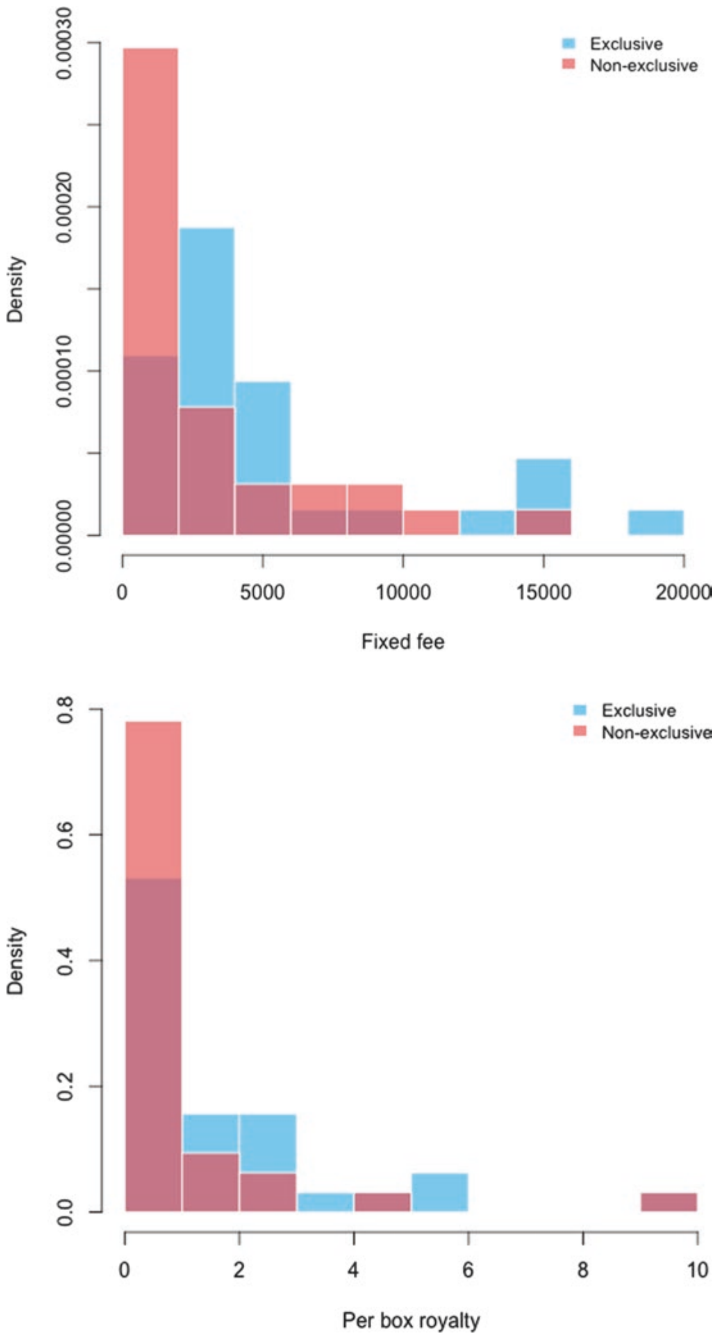


**Fig. 1** The empirical distributions of growers' bids (in $) for a new apple variety under different commercialization mechanisms

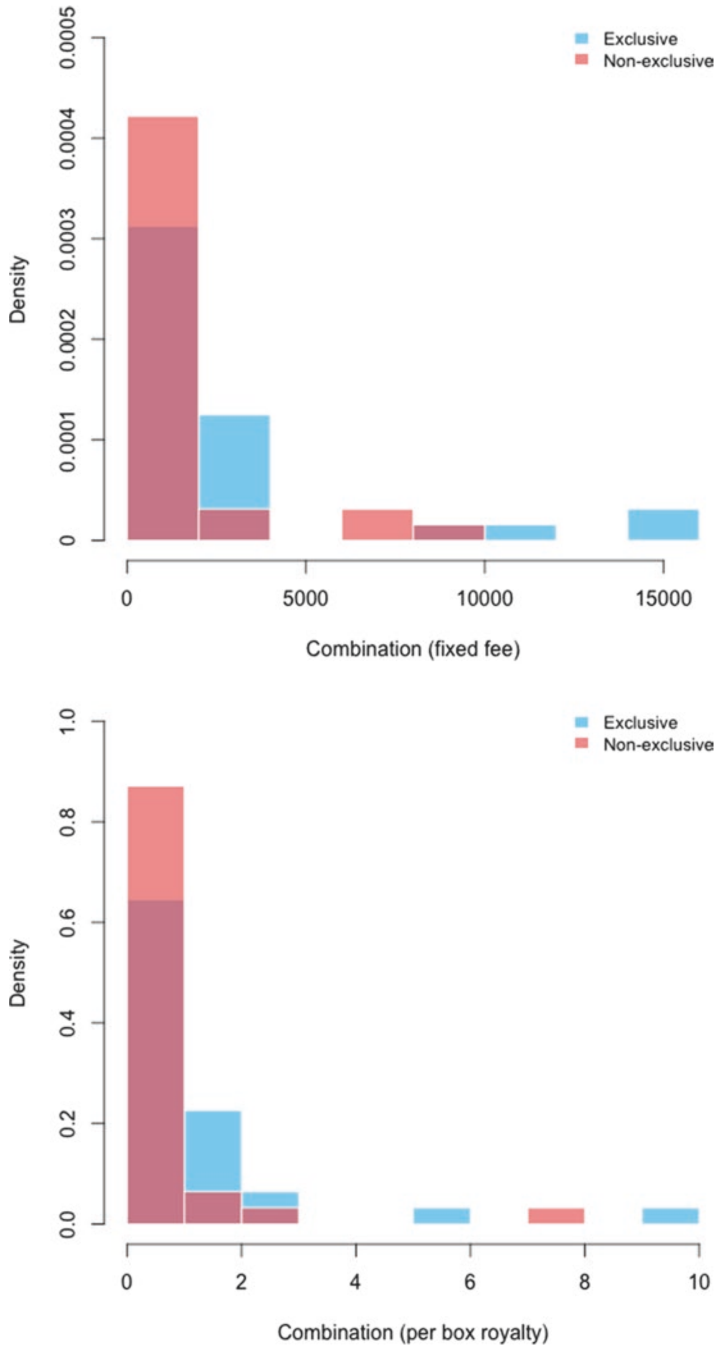


**Fig. 1** (continued)

can observe that most of the weights for fixed fee and per-box royalty under two-part tariff, i.e., combination (fixed fee) and combination (per-box royalty), respectively, fall to the lower tail relative to stand-alone fixed fee and per-box royalty contracts, which is intuitive.

In order to compare the relative profitability of different licensing arrangements, we compute the innovator's and licensee's costs and profits for eligible bids. We use the "Honeycrisp" cost-of-production study as the reference for understanding the likely costs of growing the new varieties (Galinato and Gallardo 2012). Eligible bids are determined based on the BDM auction approach using the binding licensing schemes and whether or not the grower's bid is greater than or equal to a randomly drawn market clearing price. We calculate 10-, 15-, and 20-year present values of profits based on production of the new apple variety on either 10% of grower's total apple land or 10 acres of land, whichever is higher.

Figure 2 depicts the variation in estimated grower profits arising from six different licensing arrangements. It is clear that the grower's profits are the greatest across three contract types (fixed fee, per-box royalty, and two-part tariff) and different time horizons when the contract is exclusive. This makes sense as the contract

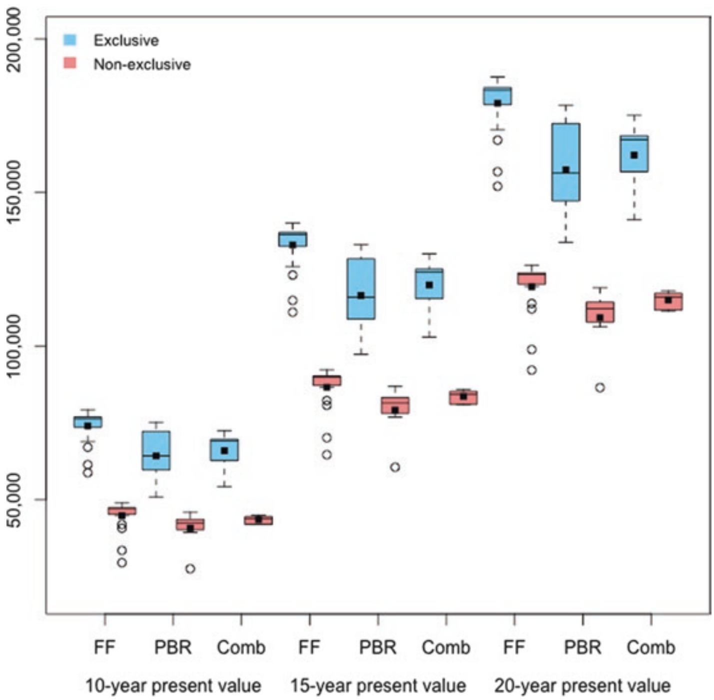


**Fig. 2** Boxplot of estimated grower profits (in $) for eligible bids under different commercialization mechanisms and time horizons. Note: The bottom and the top of the box correspond to the 25th and 75th percentiles, respectively. The horizontal line inside the box represents the median (the 50th percentile), while the small black box denotes the mean. Whiskers indicate variability outside the upper and lower quartiles. Circles denote outliers

exclusivity is the largest statistically significant nonconstant factor that affects grower bids under all three contract types. Furthermore, under both exclusive and nonexclusive contracts, the grower obtains the largest profits with the fixed fee, followed by the two-part tariff and then the per-box royalty. Our empirical findings for nonexclusive contracts support those from theoretical analysis, while the results for exclusive contracts provide partial support. In particular, for exclusive contracts, theoretical and empirical results agree on the ranking for fixed fee and two-part tariff but disagree on the ranking of per-box royalty.

The estimated innovator profits under six commercialization mechanisms are reported in Fig. 3. It is apparent that exclusive contracts are beneficial to innovators as well, a finding that is line with the literature (Sen and Taumann 2007). Moreover, under the exclusive contract, the innovator's profits are highest with the per-box royalty, followed by the two-part tariff and then the fixed fee. The profit-ranking under a nonexclusive contract remains largely the same, with the only change being in the relative position of the two-part tariff and the fixed fee for some periods. Generally, the empirical findings for nonexclusive contracts are in line with those from theoretical analysis, whereas those for exclusive contracts are in partial agreement with the theoretical predictions. Specifically, for exclusive contracts, theoretical

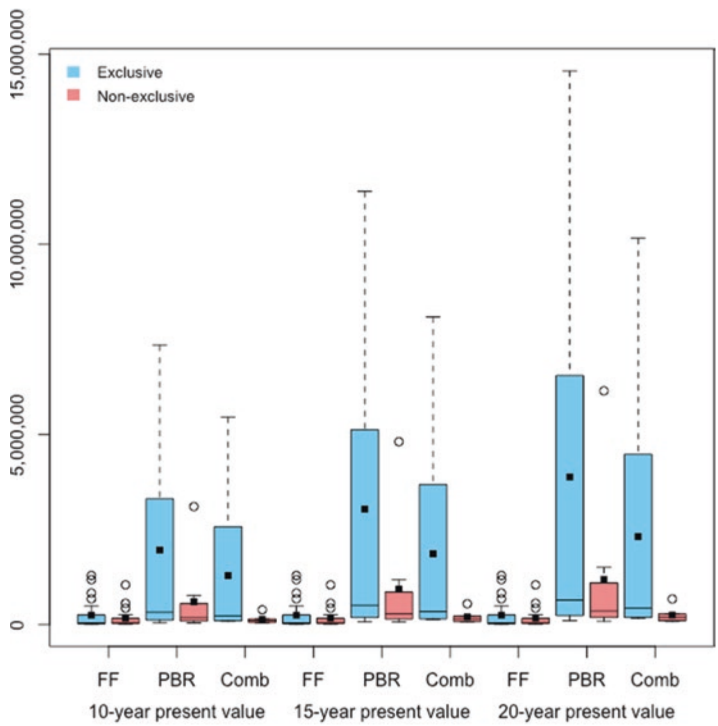


**Fig. 3** Boxplot of estimated innovator profits (in $) for eligible bids under different commercialization mechanisms and time horizons

and empirical results agree on the rankings for two-part tariff and the fixed fee but disagree on the ranking of per-box royalty.

## Conclusions and Discussion

This chapter considers the economic implications of how university plant breeding programs commercialize the new plant cultivars that they develop. New horticultural varieties are often developed by public universities that receive public funding in addition to funding from producers directly through commodity commissions. As a result, university administrators are increasingly pressed to optimize the way that they commercialize new varieties and how these decisions affect growers in their state. The real-world nuances related to these sensitivities need to be fully considered in the economic analysis of the optimal licensing strategy.

Several insights can be drawn from our work. The results provide evidence that the fixed-fee exclusive contract is the most profitable for growers. Of the nonexclusive contracts, the fixed fee contract also performs the best from the growers' perspective. For the innovator, the most preferable licensing scheme is the per-box royalty contract for both exclusive and the nonexclusive versions of the contracts. Our findings on potential profits for both adopters and innovators signal that exclusive contracts outperform the nonexclusive licensing schemes. However, there are distributional effects and fairness concerns.

The political and institutional limitations to the contracts that can be used to license new varieties being released by public universities, especially when plant breeding programs have a stated objective to make new varieties available to all growers, may make a suboptimal outcome necessary. From an economic point of view, it may be possible for the growers who benefit from exclusive access to compensate the growers who do not have access with all parties being better off relative to providing open access to all growers. Findings from our research warrant further in-depth research of this complex and contrasting situation.

## References

Akhundjanov, S.B., K.R. Gallardo, J.J. McCluskey, and B.J. Rickard. 2017. Optimal Licensing of Plant Variety Patents: Benefiting both the Public University and the Industry. Working Paper, Washington State University.

Alston, J.M., and P.G. Pardey. 2008. Public Funding for Research into Specialty Crops. *HortScience* 43 (5): 1461–1470.

Alston, J.M., M.A. Andersen, J.S. James, and P.G. Pardey. 2010. *Persistence Pays: US Agricultural Productivity Growth and the Benefits from Public R&D Spending*. New York: Springer. Available at: http://www.springerlink.com/content/978-1-4419-0657-1.

Arrow, K.J. 1962. Economic Welfare and the Allocation of Resources for Inventions. In *The Rate and Direction of Inventive Activity: Economic and Social Factors*, ed. R.R. Nelson. Princeton: Princeton University Press.

Bareuther, C.M. 2011. Washington Apples: Variety Report. *Produce Business* 27 (8): 42–50.
Becker, G.M., M.H. DeGroot, and J. Marschak. 1964. Measuring Utility by a Single-Response Sequential Method. *Behavioral Science* 9 (3): 226–232.
Bousquet, A., H. Cremer, M. Ivaldi, and M. Wolkowicz. 1998. Risk Sharing in Licensing. *International Journal of Industrial Organization* 16 (5): 535–554.
Brown, S.K., and K.E. Maloney. 2009. Making Sense of New Apple Varieties, Trademarks and Clubs: Current Status. *New York Fruit Quarterly* 17 (3): 9–12.
Cahoon, R.S. 2007. Licensing Agreements in Agricultural Biotechnology. In *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices*, ed. A. Krattiger, R.T. Mahoney, L. Nelsen, J.A. Thomson, A.B. Bennett, K. Satyanarayana, G.D. Graff, C. Fernandez, and S.P. Kowalski. Ithaca: Bio Developments-International Institute.
Choi, J.P. 2001. Technology Transfer with Moral Hazard. *International Journal of Industrial Organization* 19 (1–2): 249–266.
Fauli-Oller, R., and J. Sandonis. 2002. Welfare Reducing Licensing. *Games and Economic Behavior* 41 (2): 192–205.
Galinato, S., and R.K. Gallardo. 2012. 2011 Cost Estimates of Establishing, Producing, and Packing Honeycrisp Apples in Washington. Washington State University Extension Factsheet FS062E.
Gallardo, R.K., D. Nguyen, V. McCracken, C. Yue, J. Luby, and J.R. McFerson. 2012. An Investigation of Trait Prioritization in Rosaceous Fruit Breeding Programs. *Hortscience* 47 (6): 771–776.
Gallini, N.T., and B.D. Wright. 1990. Technology Transfer Under Asymmetric Information. *RAND Journal of Economics* 21 (1): 147–160.
Huffman, W.E., and R.E. Just. 1999. The Organization of Agricultural Research in Western Developed Countries. *Agricultural Economics* 21 (1): 1–18.
Just, R.E., and W.E. Huffman. 2009. The Economics of Universities in a New Age of Funding Options. *Research Policy* 38 (7): 1102–1116.
Kamien, M.I., and Y. Tauman. 1986. Fees Versus Royalties and the Private Value of a Patent. *Quarterly Journal of Economics* 101 (3): 471–492.
Kamien, M.I., and Y. Tauman. 2002. Patent Licensing: The Inside Story. *The Manchester School* 70(1): 7–15.
Kamien, M.I., S.S. Oren, and Y. Tauman. 1992. Optimal Licensing of a Cost Reducing Innovation. *Journal of Mathematical Economics* 21 (5): 483–508.
Katz, M.L., and C. Shapiro. 1986. How to License Intangible Property. *The Quarterly Journal of Economics* 101 (3): 567–589.
Lehnert, R. 2010. Not so sweet tangle: Minnesota growers sue over club agreement. Good Fruit Grower (August 2010): 8–9. Available at: http://www.goodfruit.com/Good-Fruit-Grower/August-2010/Not-so-sweet-shytangle/.
Li, C., and J. Wang. 2010. Licensing a Vertical Product Innovation. *The Economic Record* 86 (275): 517–527.
Milkovich, M. 2011. Litigants Settle SweeTango Dispute. *Fruit Grower News* (November 2011).
Mussa, M., and S. Rosen. 1978. Monopoly and Product Quality. *Journal of Economic Theory* 18 (2): 301–317.
Muto, S. 1993. On Licensing Policies in Bertrand Competition. *Games and Economic Behavior* 5 (2): 257–267.
Rickard, B.J., T.J. Richards, and J. Yan. 2016. University Licensing of Patents for Varietal Innovations in Agriculture. *Agricultural Economics* 4: 3–14.
Saracho, A.I. 2002. Patent Licensing Under Strategic Delegation. *Journal of Economics and Management Strategy* 11 (2): 225–251.
Sen, D. 2005. On the Coexistence of Different Licensing Schemes. *International Review of Economics and Finance* 14 (4): 393–413.
Sen, D., and Y. Tauman. 2007. General Licensing Schemes for Cost-Reducing Innovation. *Games and Economic Behavior* 69: 163–186.
Shapiro, C. 1985. Patent Licensing and R&D Rivalry. *American Economic Review* 75(2): 25–30.