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# Copyright or copyleft: An assessment of farmer-innovators' attitudes towards intellectual property rights

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ABSTRACT

There is a broad consensus that farmers are not simply recipients of promoted techniques: rather, they are also an important source of agricultural innovations. They invent farm tools and equipment, develop new crop varieties, and add value to externally promoted technologies. When scouting, documenting and promoting such farmer-generated innovations, the thorny issue of intellectual property rights (IPRs) often emerges. Using data from 300 farmer-innovators in Kenya, Malawi and Zambia, this study seeks to contribute to a better understanding of farmers' knowledge of and preferences for IPRs and open-access innovation. Results show that more than half of the innovators have no prior knowledge of IPRs. We found evidence that small-scale farmer-innovators prefer their innovations to be open access rather than protected by IPRs, and this is largely driven by altruistic motives. Some of the reasons cited by the farmers for preferring IPR protection include obtaining financial benefits, recouping the money invested in developing the innovation, wanting to be recognized as the original innovator, and preventing piracy. Consistent with the innovators' stated reasons, results from a bivariate probit regression show that the commercialization potential of and cost incurred in developing an innovation are among the key correlates of the preference for IPRs.

## 1. Introduction

There is a general understanding that farmers are not only recipients of introduced technologies: rather, they are also an important source of agricultural innovations (Sumberg and Okali, 1997; Reij and Waters-Bayer, 2001; Bentley, 2006; Gupta, 2016). They invent new farming tools; develop new crop varieties through several years of seed selection and experimentation; add value to externally promoted technologies to adapt them to their farming conditions; or substantially improve upon traditional or common practices to adapt to global changes (Reij and Waters-Bayer, 2001; Bentley, 2006; Tambo and Wünscher, 2015). The innovations developed by farmers (which are commonly known as farmer-generated innovations) play an important role in improving the livelihoods of farm households and in maintaining genetic diversity, and they can provide inputs for scientific innovations or even form the basis for scientific breakthroughs (Röling, 2009; Tambo and Wünscher, 2017). In recent decades, development agents, researchers and policy-makers have recognized the importance of farmer-generated innovations, and their interests have resulted in the development of a number of initiatives to support farmer innovation processes. For instance, the Honey Bee network in India has scouted and documented over 70,000 grassroots innovations and has spawned other institutions that provide support to the network (Gupta, 2009). Similarly, the Prolinnova network has been fostering the development of local innovation processes in agriculture and natural resource management in about 20 countries in Africa, Asia and Latin America (Wettasinha et al., 2008).

In the process of scouting, documenting and disseminating farmer innovations, issues of Intellectual property rights (IPRs) often emerge. It is not uncommon to find participants in a workshop on farmer innovations engaging in discussions about the need for and the challenges posed by IPR protection. Are farmer-innovators aware of their IP rights? Would they prefer to seek IPR protection for their innovations? How can farmers who have developed innovations recoup their investment costs, and how do we prevent piracy of their knowledge and resources? These questions are of interest to proponents of farmers' rights, as well

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as for scientists and development agents who are interested in traditional knowledge and farmer-generated innovations. Answers to these questions have important implications for the promotion of farmer innovation processes.

IPRs grant inventors exclusive rights to prevent the unauthorized commercial use of their inventions for a specified period within a geographic jurisdiction. The scope of rights granted to the inventors depends on the IPR regime. The extent to which IPRs encourage agricultural innovation is a subject of intense debate. Studies have shown that IPRs increase genetic improvement, promote the generation of high-yielding varieties, enhance crop productivity, increase the likelihood of innovations occurring, and promote yield gap convergence between developed and developing countries (Kolady and Lesser, 2009a,b; Kolady et al., 2012; Kim and Kapstein, 2015; Spielman and Ma, 2016). However, other studies argue that there is little to no evidence that IPRs increase innovation (van Wijk, 1996; Boldrin and Levine, 2008; Hall and Harhoff, 2012). Moreover, a number of civil society, farmer and development organizations have opposed instituting strong IPR protection for agriculture in developing countries for reasons including: the type of innovation stimulated by IPRs is not beneficial to majority of smallholder farmers (Smith and Bragdon, 2016); stringent IPR regimes contribute to the erosion of agrobiodiversity (Kuyek, 2002; Peschard, 2017); invention is cumulative, and IPRs increase the cost of inventions that build on earlier innovations (Kuyek et al., 2001); and some IPRs enable the piracy of farmer innovations, because farmers' contributions to the conservation of plant genetic resources, which may form the basis of externally-developed innovations, are often overlooked (Kuyek, 2002; Wekesa, 2006).

In recent years, there has been considerable interest in IPR protection for farmer innovations and traditional knowledge. For instance, the UN Convention on Biological Diversity (Frisvold and Condon, 1998), the FAO Resolution 5/89 on Farmers' Rights (FAO, 2017) and the Plant Variety Protection laws of a number of countries, such as Costa Rica, India, Malaysia and Thailand (Smith and Bragdon, 2016) acknowledge farmers' contributions to agricultural innovations. Farmers are therefore thought to be deserving of the same recognition and rewards as plant breeders, seed companies and other inventors (Ramanna and Smale, 2004). Generally, farmers innovate out of curiosity, the desire for social recognition, interest in increasing production and to take advantage of new opportunities, or the need to adapt to agricultural challenges, such as soil infertility, and pests and diseases (Bentley, 2006; Tambo, 2018). Nonetheless, IPR protection could encourage them to devote more resources to inventive activities and thus generate more innovations.

However, there is no consensus on whether IPRs are appropriate for farmer-innovators and what effect IPR protection has on farmer innovation systems. While some believe that grassroots innovations should be placed in the public domain and be free of any IPR restrictions, others argue that farmers should also benefit from their inventions through IPR protection. For example, there are claims that traditional knowledge-holders are willing to forego their IPRs, provided their contributions are adequately recognized (e.g. through awards and public recognition) (Abay et al., 2009). Additionally, it is argued that imposing IPRs is often not feasible or desirable and could restrict access to innovations by other smallholders and thus undermine farmer-led innovation processes (Wettasinha et al., 2008; Waters-Bayer et al., 2009). Gupta (2007), however, asserts that IPR protection enables private firms to add value to grassroots innovations and subsequently share the benefits with the local innovators, and that it also prevents the piracy of their traditional knowledge. In a recent study on IPRs, Smith and Bragdon (2016) contend that some IP regimes such as the *sui generis* system of plant breeders' rights (PBR), trademarks and geographical indications have the potential to promote farmer innovations, while others such as patents, trade secrets and the International Union for the Protection of New Varieties of Plants (UPOV)-based PBR can have detrimental effects on smallholder farmers' innovation systems.

As Wettasinha et al. (2008) noted, the first step in approaching the complex issue of IP protection for farmer innovations is to understand how farmers perceive these rights and to stimulate deliberation on the topic among stakeholders. However, in practice, the views of the innovators themselves are rarely considered. The scant literature on this subject is mostly based on expert opinions and betrays an incomplete understanding of farmers' perspectives on the topic (Wettasinha et al., 2008). This paper seeks to contribute to a better understanding of farmer-innovators' awareness of and attitudes towards IPRs or the free sharing of innovations. The findings will be relevant to governments, civil society organizations and other actors interested in promoting farmer-led innovations, particularly in many developing countries where IPR systems are not well-developed. Specifically, we analyze the determinants of farmer-innovators' choice between open access and IPR protection. Innovators' stated preferences for (or against) IPR protection are also reported and discussed. The study is based on survey data from 300 farmer-innovators in Kenya, Malawi and Zambia.

It should be mentioned that in this study, the term "open access" or "free-sharing" denotes that the innovations can be freely used or modified by others without the restrictions imposed by IPRs. We note that it is possible to grant IP rights to innovators who then make their innovations openly accessible through the requirement of public disclosure, through creative commons licencing, or through other mechanisms. Hence, it should be stressed that the term "open access" as used in this study precludes the type of open access granted by IPRs under the requirement of public disclosure, but it rather implies that the innovators are not interested in seeking any form of IPRs and that others are allowed to use, modify or share the innovations without restrictions.

The rest of the paper is organized as follows. Section two provides a review of the literature on IPRs in relation to agricultural innovations. The third section presents the data and empirical methods. Descriptive and empirical results are presented and discussed in section four, and section five concludes the paper.

## 2. Relevant literature

### 2.1. IPR institutions and instruments

There are two main theoretical justifications invoked in any discussion of IPRs, one utilitarian, and the other, rights-based (Menell, 2000). In the former, granting an agent a monopoly over her innovation has instrumental value. The argument is as follows: innovation is a costly process which requires the innovator to make irreversible investments (i.e. in the form of research and development). If other individuals or firms can then appropriate this innovation and produce it for the market, they will be able to price it lower than the initial inventor, who must recover his initial costs. Therefore, in a society without intellectual property protection, there will be too little innovation relative to the socially optimal level because individuals or firms will be unwilling to make the necessary initial investments. The rights-based approach sees intellectual property in much the same way as physical property and, consequently, ascribes intrinsic value to IPRs. Since time and energy is devoted to the process of innovation, innovators are considered to have 'rights' to exploit the resulting product or process, including the right to exclude others from its use.

It is from one or both these standpoints that IPR regimes are developed and justified. These are determined at the national level and are codified in the legal system. Nevertheless, in a world characterized by accelerating trade flows, international institutions and agreements have been established to attempt to harmonize rules and practices for the protection of IPRs. Of notable importance are the World Intellectual Property Organization (WIPO), which is a forum for UN member states, and the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), which applies to members of the World Trade Organization (WTO). In the world of plant breeding, the International

Union for the Protection of New Varieties of Plants (UPOV) is of importance in that it provides guidelines aimed at harmonizing agriculture-related IPRs across countries (UPOV, 2011; Breitwieser and Foster, 2012).

A range of IPR instruments or tools are available for the protection of farmer innovations. The common ones include patents, plant variety protection, trademarks, trade secrets and geographical indications (Smith and Bragdon, 2016). The main benefits of patents as they relate to agricultural innovations is that their disclosure requirements disseminate knowledge and can consequently spur further research efforts; that they facilitate efficient knowledge and economic transfers from innovators to parties capable of exploiting the innovation through licensing; and that patents on locally developed plant varieties can discourage biopiracy (Clancy and Moschini, 2013; Wekesa, 2006). Nevertheless, the economic, time, and capacity-related costs of patenting, monitoring and defending potential infringements make patents prohibitively difficult for farmers to obtain. The importance of farmers' rights to the protection of plant varieties resulting from their inventive activity is recognized in the FAO Council Resolution 5/89, which codifies their "rights arising from the past, present and future contributions of farmers in conserving, improving and making available plant genetic resources, particularly those in centres of origin/diversity" (FAO, 2017 pg. 12–13). Farmers may also protect their innovations through secrecy, and benefit from trade secret rules that protect against unauthorized access to a production secret. Although no registration is required for this type of IPR, it only holds so long as the inventor can keep her innovation secret, which may not be possible or even desirable for small farmers. An obvious consequence of trade secrets is that they obstruct the dissemination of knowledge, which can be beneficial to development or have positive spillover effects for an entire community. Trademarks can be used to indicate higher value products and to build a reputation, but this is generally contingent on the existence of an international market, a developed value-chain, and informed consumers (Smith and Bragdon, 2016). Geographical indications (GIs) are a form of IPR consisting of a mark associated with certain products originating from a specific geographical area (Dewan, 2011). As with trademarks, these may provide a signal of quality and the opportunity to sell at a higher price, but they demand a degree of financial and organizational capacity that may not be feasible for many rural communities (Smith and Bragdon, 2016).

Thus, the various IPR instruments can potentially advance or hinder the goal of fostering and protecting farmer innovations and increasing the overall level of innovation in society. We refer readers to Smith and Bragdon (2016) for a comprehensive assessment of the potential of each of these IPR tools to contribute to or negatively impact farmer innovation systems. We also note there is the possibility of preventing piracy of farmer innovations not through IPR but through protective documentation, in that once an innovation is documented and the information is put in the public domain, others cannot later claim sole ownership of it (Wettasinha et al., 2008).[1]

### 2.2. IPRs in the study countries

Kenya became a member of WIPO in 1994, and, as a founding member of the WTO in 1995, the country has been subject to the intellectual property regulations outlined by TRIPS (Wekesa and Sihanya, 2009). The main institutions engaged in the administration and enforcement of IPRs in Kenya are the Anti-counterfeiting Agency, the Kenya Industrial Property Institute (KIPI), and the Kenya Copyright Board (KECOBO). Kenya is generally considered to have a robust IPR framework, but enforcing these laws remains a challenge due to limited staffing and resources (Exportgov, 2017). Relating to agriculture, Kenya is a member of UPOV, and the convention's 1991 regulations came into force in the country in 2016. Additionally, Kenya's 2006 Environmental Management and Coordination Act pertains to the conservation of biodiversity and resources, access to genetic resources and benefit sharing (WIPO, 2017). Finally, Kenya has an act protecting traditional knowledge and cultural resources against misuse and misappropriation[2] (Wanzala, 2016).

Malawi has been a member of WIPO since 1978. Nonetheless, its IPR regime is not as strong as Kenya's. Due to its status as a least developed country, Malawi has until 2021 to fully implement TRIPS requirements, and is currently working to update, strengthen and harmonize its intellectual property regime. In 2014, a bill was drafted that would enable the creation of a Malawi Intellectual Property Office (Zakeyo, 2014). Malawi does not yet have its own patent examiners; this task is currently overseen by the African Regional Intellectual Property Organization. The country is currently in the process of adhering to UPOV, and is harmonizing its laws to conform to the convention's requirements (UPOV, 2017). Of all the agreements it has taken part in, the International Treaty on Plant Genetic Resources for Food and Agriculture is the only one that recognizes farmers' rights, and these remain absent from the country's existing PBR laws (Utviklingsfondet, 2014). The lack of human and monetary resources and the limited public awareness and legal competency in this field represent key challenges to the implementation and protection of IPRs in Malawi.

Zambia established its own Intellectual Property Office at the end of the federations of Rhodesia and Nyasaland in 1968 (Thole, 2017). It has been a member of WIPO since 2001 and is party to the main international intellectual property agreements (Exportgov, 2017). Recent developments in Zambia's intellectual property laws include the inclusion of petty patents under patent laws, the recognition of Geographical Indications for agricultural products, and an act protecting traditional knowledge and cultural heritage[3] (Thole, 2017). In terms of enforcement, the Zambia Police service has an intellectual property unit, which conducts raids and confiscates material in violation of intellectual property laws (Exportgov, 2017). Zambia regulates plant varieties and offers protection to plant breeders through its Plant Breeders Act of 2007. However, there were no regulations in place when it came into effect, meaning that applications could be neither accepted nor processed (Spoor & Fisher, 2012). This act remains to be amended, and Zambia is currently engaged in initial discussions with UPOV in order to harmonize its laws to comply with the convention (UPOV, 2017).

### 2.3. IPR applications to foster farmer innovation

Two competing narratives have emerged in the field of farmer innovations, born from two organizations with the shared goal of promoting local innovation. Though both organizations seek to encourage, compile and disseminate the benefits from small-scale local innovations, their points of view regarding the potential for IPRs to contribute to their mission differs widely. Honey Bee network and its affiliate organizations in India [the Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) and the National Innovation Foundation (NIF)] advocate for using IPRs to register farmer innovations. Prolinnova network, on the other hand, advocates for a 'copyleft' approach. Both their approaches are detailed in this section.

Honey Bee network's IPR philosophy draws heavily on the conception of intellectual property as analogous to physical property. This possession of knowledge consequently gives rise to moral rights over that 'property', which is why the network argues that it prefers to operate within the IPR framework by assisting farmers in obtaining IPRs.

[1] We thank an anonymous reviewer for pointing out this possibility of protecting farmer-generated innovations.

[2] The Protection of Traditional Knowledge and Cultural Expressions Act, 2016

[3] Protection of Traditional Knowledge, Genetic Resources and Expressions of Folklore Act, 2016

Since all innovations do not necessarily fit the requirements for IPRs, the network avows that it is also committed to ensuring that innovators receive fair compensation for their knowledge in one way or another and are not short-changed (Gupta, 2007). The NIF, which is part of the Honey Bee network and is affiliated with the Department of Science and Technology of the government of India, claims that it has so far filed 850 applications for patents, farmers' plant variety registration applications, and 10 trademark applications, of which 42, 5, and 0 have so far been granted (NIF, 2017). The network and its affiliates see IPRs as tools in the mission to enrich the public domain, with the end goal of benefiting society at large. This is evidenced in SRISTI's guidelines for benefit sharing; farmers and innovators who receive material gains from their innovation through their involvement with the network are encouraged to share those gains with the community through a normative benefits-sharing formula, which outlines set percentages to contribute to different initiatives. These include but are not limited to the innovation fund, the innovator's community, nature, and a women's fund (Gupta, 2016). This reflects an underlying understanding of intellectual property as a manifestation of rights that come bundled with responsibilities towards the parties who contributed to the development of innovations.

The Honey Bee network's philosophy can be summarized as centering on the rights of the innovator, i.e. properly compensating the innovator for his/her innovation, which creates secondary innovation-promoting effects. The rights-holder can then compensate any factors or agents who may have implicitly contributed to the innovation's development through the benefits sharing scheme, which is implemented at the innovator's discretion. The role of IPRs is therefore triple; they represent the rights of the innovator over her intellectual property, and are a means of appropriately compensating the main innovator as well as any contributing agents (intrinsically positive); they represent a prize that spurs investment in innovative activities and their reporting (instrumentally positive); and the gains they confer to the innovator and the community at large can be reinvested into the innovation system (instrumentally positive).

Prolinnova network embraces the concept of ‘copyleft,’ which “uses copyright laws to remove restrictions on copying and modifying published work and requires that the modified versions enjoy the same freedom” (Wettasinha et al., 2008, pg. 21). By encouraging innovators to piggy-back on each other's inventions and encouraging cross-disciplinary collaboration between farmers, development agents, and research scientists, the network hopes to refine local innovations and encourage others to try them out (ibid.). In their view, the current IPR system represents an obstacle to the free flow of information, the latter being crucial to the spawning of innovation. The network asserts that it places at the heart of their philosophy the process of innovation itself, which they see as fundamentally participatory in nature. Under this framework, knowledge is considered a non-excludable right and a public good, making ‘intellectual property’ an inherently contradictory concept. Any benefit generated from innovations is a result of the application of the innovation itself, and the total benefit to society is multiplied with every person that uses it and improves upon it. IPRs are therefore seen as a violation of the right to information (intrinsically negative) and an obstruction of the creative process through which innovation flourishes (instrumentally negative).

## 3. Methods

### 3.1. Data

The empirical analysis is based on data obtained from 300 farmer-innovators in Kenya, Malawi and Zambia. The farmer-innovators were identified through innovation contests that were implemented in 2016 in the three countries as part of the Program of Accompanying Research for Agricultural Innovation’ (PARI) project under the German government's “One World No Hunger” special initiative. In the contests, smallholder farmers competed to win prizes ranging from 500 USD to 1000 USD by revealing their independently developed innovations, which we defined as a practice or technique along the food value chain that is different from commonly known practices and was developed primarily by a farmer or group of farmers. The contests were implemented in three counties/districts each across the three countries in collaboration with local partners, including Non-Governmental Organizations (NGOs), research institutions, farmer organizations, extension service providers and ministries of agriculture.

The study areas include Bungoma, Kakamega and Siaya counties in Kenya; Choma, Katete and Petauke districts in Zambia; Rumphi, Salima and Thyolo districts in Malawi. Most households in the districts are engaged in smallholder farming and are involved in the production of traditional food crops (mainly cereals and pulses) and livestock. In some of the districts, farmers also produce cash crops such as tea, tobacco, coffee, cotton and sugar cane. The 300 farmer-innovators were interviewed face-to-face by agricultural extension officers who were trained as enumerators. They interviewed the eligible innovators using structured questionnaires that also served as application forms for participation in the contests. The questionnaire captured data on the socio-economic characteristics of the innovators, the characteristics of their innovations, their awareness and preferences for IPRs, and their access to infrastructural and institutional support services. Before starting the interviews, the enumerators explained the purpose of the survey to the innovators and stressed that participation was voluntary. The innovators were asked to decide whether or not to participate in the survey, and this information was recorded on the questionnaire by the enumerators.

### 3.2. Empirical approach

As previously mentioned, the main purpose of this paper is to analyze farmer-innovators’ attitudes towards IPR protection and the free-sharing of their innovations (i.e., open access model) and to gain insight into factors that influence these attitudes. It should be stated that due to lack of data on actual choices made by the innovators on IPRs, our analysis of preferences for IPR protection versus open access is based on stated preferences rather than revealed preferences. In the stated preference survey, the attributes of IPRs and open access were read out to the innovators, and they were then asked to choose their preferred option. We acknowledge that alternative methods such as contingent valuation surveys, discrete choice experiments, or experimental auctions might have been more appropriate for eliciting the innovators’ stated preferences. Moreover, stated preference methods suffer from a number of limitations, including hypothetical bias and investigator bias, and several strategies have been proposed in the literature for mitigating such biases (Loomis, 2014). Unfortunately, the survey design did not allow us to deal with the potential methodological problems associated with eliciting stated preferences.

The data were analyzed using descriptive statistics and a regression model. We examine farmers' views on IPRs and open access model by categorising and discussing the innovators' responses according to themes. The main factors that determine farmer-innovators’ choice between IPR protection and open access can be estimated using binary response models (such as probit or logit model), since the outcome variable is dichotomous. However, given that farmer-innovators who were familiar with IPRs prior to the survey may be more likely to opt for IPR protection, we analyze the innovators’ choice as a two-stage process using a seemingly unrelated bivariate probit model (Hardin, 1997; Greene, 2018). The bivariate probit model jointly estimates the probability of awareness of IPRs and choosing IPR protection or open access while correcting for selection bias related to the potential dependence of IPR preference on awareness. Thus, the model consists of a first-stage equation (awareness stage) and a second-stage equation (preference stage). This can be expressed as:

**Table 1**
Definition of variables in the regression.

| Variable | Definition | Mean | Std. dev. |
|---|---|---|---|
| Gender | Gender of innovator (1 = male) | 0.67 | 0.46 |
| Age | Age of innovator (years) | 49.01 | 12.08 |
| Education | Educational level of innovator (years) | 9.35 | 4.44 |
| Risk attitude | Innovators' self-reported risk-taking propensity (0–10) | 8.26 | 2.22 |
| Group membership | Innovator is a member of farmer group (1 = yes) | 0.79 | 0.41 |
| Credit | Innovator has access to credit (1 = yes) | 0.53 | 0.50 |
| Radio | Innovator owns a radio (1 = yes) | 0.79 | 0.41 |
| Land size | Total land owned by innovator (hectares) | 3.22 | 5.36 |
| Value of asset holdings | Total value of non-land productive assets (1000 USD) | 1.03 | 3.75 |
| Innovation quality | Innovation is a radical improvement (1 = yes) | 0.30 | 0.46 |
| Cost of innovation | Cost of developing the innovation (USD) | 98.29 | 295.45 |
| Marketing of innovation | Innovator is already marketing the innovation (1 = yes) | 0.42 | 0.49 |
| Distance to extension | Distance from innovator's residence to the nearest agricultural extension agency (km) | 6.23 | 6.72 |
| Distance to district capital | Distance from innovator's residence to the district capital (km) | 17.13 | 16.94 |

$$A_i = 1 \; if \; [\beta X_i + \varepsilon_i > 0] \quad \text{(Awareness equation)}$$
$$Y_i = 1 \; if \; [\delta Z_i + \mu_i > 0] \text{ and } A_i = 1 \quad \text{(Preference equation)}$$
$$= 0, \text{otherwise}$$
$$\text{Corr}(\varepsilon, \mu) = \rho$$

where $A$ is the observed awareness of IPRs and takes a value of 1 if the farmer-innovator is aware of IPRs and 0 otherwise. $Y$ captures the innovator's choice between IPRs and open access, taking a value of 1 if the innovator prefers IPR protection and 0 if he/she prefers open-access innovation. $X$ and $Z$ are vectors of variables explaining the awareness of IPRs, and preferences for IPR protection or open access, respectively. The bivariate probit model corrects for selection bias by allowing the error terms in the awareness ($\mathcal{E}$) and preference equations ($\mu$) to be correlated. When the correlation between the two error terms is statistically significant (i.e., $\rho \neq 0$), applying a unitary probit or logit model to estimate the preference equation will yield biased results.

The independent variables ($X$ and $Z$) included in the bivariate probit model are presented in Table 1. These include characteristics of the innovators (age, education, gender, risk-taking propensity and wealth status), features of the innovations (marketing of the innovation, cost of developing the innovation and degree of inventiveness) and institutional factors (access to credit, information and infrastructural services). A higher level of education is expected to increase the innovator's ability to obtain, understand and utilize information related to IPRs. Therefore, highly educated innovators may be more likely to opt for IPR protection. The relationship between the age or gender of innovators and their preference for IPRs or open source are not known *a priori*. Two wealth-related variables, i.e., amount of land and the value of all productive assets owned by the innovator, are included in the models. Wealthier innovators are expected to prefer IPR protection, as they may be in a better position to afford the transaction costs associated with IPR protection. However, it is also possible that affluent innovators are not interested in benefiting financially from the innovations, and, therefore, may opt for the free sharing of their innovations. We also examine how the distribution of innovators' risk preference is correlated with their preference for IPR protection or open access. We measure the innovators risk tolerance using a survey-based approach. Following Dohmen et al. (2011), the following survey question was posed to the innovators: "How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please choose a number on a scale between 0 and 10, where 0 means not at all willing to take risks and 10 means very willing to take risks". Though this approach is hypothetical, it has been widely validated for the elicitation of an individual's attitude towards risk (Roe, 2015).

We assess whether the cost of developing the innovation is correlated with IPR preference by asking the innovators to subjectively indicate the cost incurred from generating the innovation. We hypothesize that the higher the investment cost, the more likely the innovator will be willing to seek IPR protection. We also examine whether the innovators that are benefiting financially from their innovations are more likely to pursue IPR protection. We expect those whose innovations have commercial potential to have a higher probability of protecting their innovations through IPRs. We also control for the quality of innovations by including a subjective variable that measures whether the innovation is judged to be either a radical or incremental improvement by a trained enumerator, where incremental improvement involves the substantial modification of existing technologies or practices and radical improvement indicates the development of novel products or processes.

Regarding institutional factors, we hypothesize that innovators who are members of farmer associations may have better access to information and institutional support; hence, they may be more likely to seek IPR protection. Similarly, innovators with access to credit may have the financial ability to protect their innovations. We use proximity to district capital as a proxy to capture easy access to institutional support services, since institutions that provide administrative and regulatory services are generally situated in district capitals. We also include a variable measuring proximity to agricultural extension agency, which is a key source of information for farmers in rural areas. Finally, we add country dummies to control for country-specific unobserved heterogeneity.

It is important to stress that we are not attempting to infer causal relationships based on our bivariate probit estimation, considering that some of the covariates are potentially endogenous. Instead, our analysis aims at understanding the correlates of farmer-innovators' preferences of IPRs and open-access innovation.

## 4. Results and discussion

### 4.1. Descriptive analysis

Table 1 outlines the description of the variables used in the regression and their mean values. It shows that majority of the innovators are middle-aged men, with an average of nine years of formal education. The innovators have a high level of risk tolerance, which is expected, since innovation-generating activities of farmers generally involve some degree of risk (Tambo and Wünscher, 2017). Nearly 80% of the innovators are members of farmer groups, and about 47% of them are credit-constrained. The innovators have small land holdings, with an average land size of about 3 ha. In response to the question on quality of innovation, 30% and 70% of the innovations were deemed to be radical and incremental improvements, respectively. The average cost of developing an innovation, as estimated by the innovators, is just under 100 USD. The costs incurred by farmers in developing innovations are usually low, as farmers rely heavily on locally available

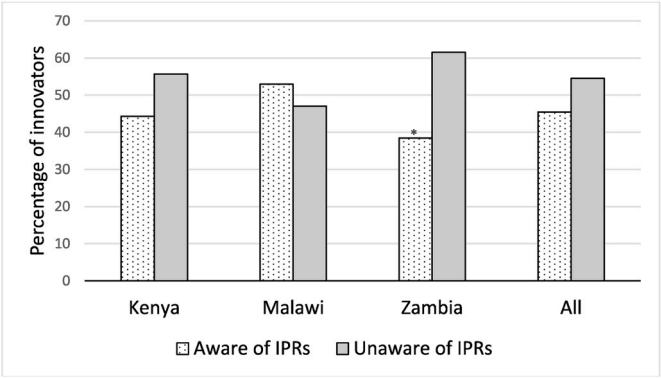


**Fig. 1.** Awareness of IPRs.Note: * indicates that the percentage difference between innovators who are aware of IPRs and those. who do not is statistically significant at the 10% level.

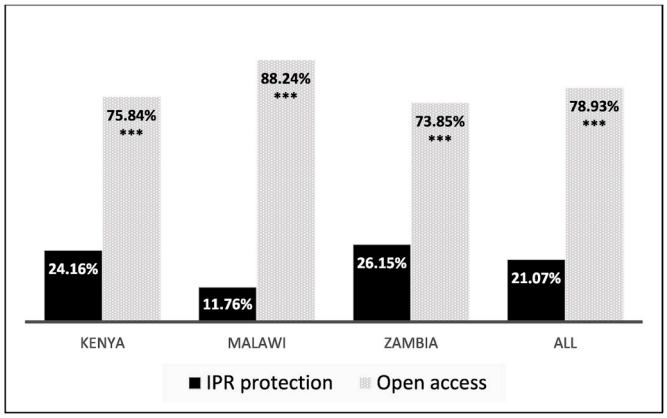


**Fig. 2.** Choice between IPR protection and open access. Note: *** indicates that the percentage difference between innovators who prefer IPR protection. and those who prefer open access is statistically significant at the 1% level.

resources (Reij and Waters-Bayer, 2001). About 42% of the innovators have already transformed their innovations into commercial products or are providing their innovation as a service in exchange for money. Table 1 also shows that the innovators have to travel an average of 6 km to access extension services and 17 km to access institutional support services in the capital of an administrative district.

Fig. 1 depicts the level of awareness of IPRs among the sampled farmer-innovators. The results show that about 45% and 38% of the farmer-innovators were aware of IPRs in Kenya and Zambia, respectively. Conversely, relatively more of the innovators that were surveyed in Malawi were aware of IPRs (52%). Overall, about 55% of the innovators had never heard of IPRs. The 45% of the innovators that had prior awareness of IPRs were asked to indicate their source of information about IPRs, and their responses are summarized in Table 2. The results indicate that in all three study countries, a majority (63%) of the innovators learnt about IPRs through the media, which includes radio, television and newspaper. Media as a source of information on IPRs is particularly important in Malawi and informed 82% of the innovators who indicated they had prior information of IPRs. Informal discussions with some of the innovators and extension workers in Malawi suggest that there are frequent discussions about IPR-related topics on the radio. Apart from the media, other sources of information on IPRs include agricultural ministries and extension services, research institutes, friends or relatives, IPR organizations, the country's constitution and workshops. We also find some differences in information sources across the countries. For instance, some of the innovators in Kenya reported that they gained knowledge about IPRs by reading the constitution or by interacting with regulatory authorities such as the KIPI. Agricultural extension workers are an important source of information on IPRs in Kenya and Zambia, while friends and relatives are also useful sources in Zambia.

Findings about farmer-innovators' preferences between IPR protection and open-access innovation are presented in Fig. 2. Most innovators (79%) would prefer to share their innovations freely with fellow farmers and stakeholders, while 21% of them would prefer to pursue IPR protection. Disaggregating by country, the results show that about 76%, 88% and 74% of the sampled innovators in Kenya, Malawi and Zambia, respectively, prefer the free sharing of innovations as opposed to IPR protection. We also find that compared to Kenya and Zambia, relatively more of the sampled innovators in Malawi opted for open access. During the survey, we found that two of the innovators in Kenya have already applied for IPR protection. These findings corroborate assertions that small-scale farmer-innovators are generally willing to relinquish their IPRs in favour of open dissemination (Wettasinha et al., 2008; Abay et al., 2009).

**Table 2**
Sources of awareness of IPRs.

| | Kenya | Malawi | Zambia | All |
|---|---|---|---|---|
| Media | 50.0 | 82.4 | 63.0 | 62.9 |
| Ministry of Agriculture/Extension services | 20.6 | 2.2 | 11.1 | 12.9 |
| Research Institute/Scientists | 2.9 | 2.2 | 3.7 | 2.1 |
| Friends and relatives | 5.9 | 2.2 | 14.8 | 6.4 |
| IPR regulatory agencies | 8.8 | 2.2 | 0.0 | 5.0 |
| Constitution | 5.9 | 0.0 | 0.0 | 2.9 |
| Workshop | 5.9 | 4.4 | 0.0 | 4.3 |
| Books | 0.0 | 4.4 | 3.7 | 2.1 |
| Others | 0.0 | 0.0 | 3.7 | 1.4 |

### 4.2. Regression results

The upper part of Table 3 reports the correlates of farmers' awareness of IPRs. We find that among the factors that are significantly associated with awareness of IPRs include the gender and level of education of innovator, access to credit, distance to extension service provider and the country dummies. The results indicate that male innovators are about 16% more likely to be aware of IPRs than female innovators. This is not surprising as women in agriculture are largely information-constrained and tend to be neglected by information and service providers (Kristjanson et al., 2017). We find that innovators' with high levels of education are significantly more likely to be aware of IPRs, probably because education enhances farmers' ability to seek out and understand information about IPRs. Innovators with access to credit are about 12% more likely to have heard of IPRs, suggesting that credit constraints inhibit innovators' access to information. Proximity to an extension service provider is significantly associated with awareness of IPRs. This is expected since extension workers are key sources of information for many smallholders in Africa. The results also show that compared to innovators in Kenya, innovators in Malawi and Zambia are significantly more aware of IPRs. Specifically, innovators in Zambia and Malawi have a roughly 19% and 23% higher chance, respectively, of having heard of IPRs than innovators in Kenya.

The regression results of the factors that influence farmer-innovators' choice between IPR protection and open-access innovation are shown in the lower panel of Table 3. Commercial interest is among the most important drivers of the innovators' preference for IPR protection. We find that innovators that are already marketing or benefiting financially from their innovations are about 8% more likely to prefer IPR protection over making their innovations freely available to the public. This may be suggestive that innovators that have transformed their innovations into marketable products would like to capture the commercial value of their innovations and, hence, may be less inclined to provide open access to their works. Results also show that

**Table 3**
Bivariate probit estimates of awareness and preference for IPRs.

| | Marginal effect | Robust std. error |
|---|---|---|
| *Awareness model* | | |
| Gender | 0.157** | 0.065 |
| Age | −0.002 | 0.002 |
| Education | 0.016** | 0.008 |
| Risk attitude | 0.002 | 0.014 |
| Group membership | 0.058 | 0.079 |
| Credit | 0.122* | 0.064 |
| Distance to district capital | −0.004 | 0.002 |
| Radio | −0.003 | 0.079 |
| Land size | −0.003 | 0.006 |
| Value of asset holdings | 0.006 | 0.007 |
| Distance to extension | −0.015*** | 0.005 |
| Malawi | 0.233*** | 0.076 |
| Zambia | 0.189** | 0.094 |
| Constant | −0.761 | 0.632 |
| *Preference model* | | |
| Gender | −0.020 | 0.044 |
| Age | 0.000 | 0.002 |
| Education | 0.009* | 0.005 |
| Risk attitude | −0.023*** | 0.007 |
| Group membership | 0.075* | 0.043 |
| Credit | −0.063* | 0.037 |
| Distance to district capital | −0.001 | 0.001 |
| Radio | 0001 | 0.042 |
| Land size | 0.005* | 0.003 |
| Value of asset holdings | −0.009 | 0.009 |
| Distance to extension | 0.004 | 0.003 |
| Quality of invention | 0.047 | 0.038 |
| Cost of invention | 0.015** | 0.006 |
| Marketing of innovation | 0.080** | 0.038 |
| Malawi | −0.076 | 0.047 |
| Zambia | −0.033 | 0.058 |
| Constant | 2.709*** | 0.927 |
| ρ | 0.315*** | 0.108 |
| Wald $Chi^2$ | 7.632*** | |
| No. of observations | 278 | |

***, **, * represent 1, 5, and 10 percent significance levels, respectively.

the cost incurred in developing an innovation is significantly correlated with the likelihood of preference for IPR protection. Specifically, a 100 USD spent on developing an innovation is related to a 1.5% higher probability of opting for IPR protection. The education variable has a positive and statistically significant association with preference for IPR protection, implying that innovators with higher level of education are more likely to seek IPR protection.

Two of the institutional factors (i.e., group membership and credit access) included in the regression model are statistically significant correlates of innovators' choice between IPR protection and open access. However, the magnitudes of the effect sizes are small. Results show that innovators who are members of farmer organizations have a higher probability of desiring IPR protection for their innovations, probably because such innovators are more likely to have institutional support with IPR processes. Furthermore, results indicate that innovators that are not credit constrained have a higher likelihood of allowing free access to their innovations, while land-rich and risk averse innovators have a higher preference for IPR protection. Finally, unlike the awareness model, no significant heterogeneity was observed in the preference for IPR protection or open access across the three study countries. The statistical significance of the ρ variable indicates that the error terms in the awareness and preference equations are correlated. Thus, our choice of bivariate probit model is justified, as failure to account for this correlation would have biased our results.

### 4.3. Farmer-innovators' reasons for preferring IPR or open access

To support the findings of the quantitative analysis, the innovators were asked to provide reasons for their choice between IPR protection and open access. Table 4 summarizes the reasons provided by the 63 innovators who prefer IPR protection. Nearly 10% of them stated that they would like to recover the resources and time they have devoted in generating the innovation. About 35% of the innovators who would prefer to seek IPR protection chose this option because they would like to earn income from their innovations. This corroborates the findings of the econometric analysis that show that the commercial potential of a farmer-generated innovation is the most important driver of interest in IPR protection. Almost 16% of the IPR-preferring innovators argued that their choice is influenced by their desire to gain recognition for coming up with the innovation so as to obtain the associated rewards and benefits. We find that about 27% IPR-preferring innovators would like to stop the illegal duplication of their innovations and prohibit others from freely profiting off their work (i.e., prevent piracy of farmers' knowledge and innovations). Interest in the scientific verification or improvement of farmer-generated innovations before dissemination is the reason cited by 8% of the innovators for their preference for IPR protection.

**Table 4**
Reasons mentioned by innovators for preferring IPR protection.

| | Kenya | Malawi | Zambia | Overall (%) |
|---|---|---|---|---|
| Recover the opportunity costs of time and resources invested | 5 | 0 | 1 | 6 (9.52) |
| Earn money or derive financial benefits | 12 | 6 | 4 | 22 (34.92) |
| Deter illegal duplication | 12 | 4 | 1 | 17 (26.98) |
| Permit further improvement or scientific validation | 2 | 0 | 3 | 5 (7.94) |
| Desire for recognition | 6 | 0 | 4 | 10 (15.87) |
| Others | 2 | 0 | 1 | 3 (4.76) |

Overall, the main reasons for the innovators' preferences for IPR protection fall under two main categories: first, expecting to be rewarded or compensated for the intellectual efforts, time, and money expended in the innovation process; second, technical and moral concerns for quality control, reproduction and use of the innovations. As succinctly expressed by an innovator from Kenya: "It was not easy for me to come up with this innovation, so it would be unfair to allow everyone to use my idea without getting something in return". In terms of interest in preventing poor-quality imitations or in providing safe products, one of the innovators from Malawi remarked: "I would like to protect my innovation to avoid wrong usage, as interested users will have to come to me directly to learn about the innovation rather than doing trial and error".

The explanations given by the 236 innovators for their preference for open-access innovation are presented in Table 5. The main reasons provided by the innovators include altruism (76%); the opportunity to further modify the innovation (19%); and social capital and recognition (4%). The results suggest that preference for free sharing of farmer-generated innovations is mainly driven by altruistic motives. The innovators were of the view that granting open access to their innovations can potentially lead to increased agricultural productivity for small-scale farmers, which in turn can enhance the country's economic growth and environmental sustainability. These farmer-innovators understand the socio-economic environment of smallholder farmers and

**Table 5**
Reasons provided by innovators for preferring open-access innovation.

| | Kenya | Malawi | Zambia | Overall (%) |
|---|---|---|---|---|
| Altruism (betterment of others) | 82 | 57 | 37 | 176 (76.0) |
| Social capital and recognition | 9 | 1 | 0 | 10 (4.3) |
| Opportunity to improve innovation | 19 | 14 | 11 | 44 (19.0) |
| No privacy in the light of social media | 1 | 0 | 0 | 1 (0.4) |
| Not conversant with IPRs and they are costly | 1 | 0 | 0 | 1 (0.4) |

would like fellow farmers to benefit from publicly available innovations, as expressed by an innovator from Malawi who has developed a botanical pesticide: “Most of the farmers are poor; hence, they cannot afford agro-chemicals. Therefore, this innovation can assist many poor farmers”.

Some of the innovators prefer to share their innovations freely as they believe that doing so will allow more farmers to use and build upon the original innovations, and this may induce the generation of modified techniques or practices that are more effective in solving the challenges they face in their farming activities. Finally, some innovators preferred open access because they felt that, as the number of people using their innovation increases, they would develop stronger network ties and become well-respected and recognized.

### 4.4. Study limitations

Our study has some limitations that should be noted. First, due to data limitations, our empirical analysis did not focus on specific IPR instruments. Farmer innovations fall into several domains, including farm implements, crop protection, plant breeding and animal husbandry. Some of these innovations may benefit from IPR instruments, such as *sui generis* plant variety protection, trademarks and geographical indications, but may not, for example, be eligible for patents, which has the requirements of novelty, non-obviousness and usefulness (Smith and Bragdon, 2016). Therefore, aggregating the various IPR instruments and comparing with an open access model may obscure important information. Moreover, given the complexities of IPRs, it is possible that some of the innovators who were aware of IPRs prior to the survey may not have had a thorough understanding of the different forms, such as the costs and benefits involved. Finally, as previously mentioned, the data used in this study was collected as part of a survey that also aimed at identifying and rewarding outstanding farmer-innovators through innovation contests. Thus, there is a potential bias if the innovators thought their responses would influence the likelihood of winning of prizes through the contests. Given the extensive training of the survey enumerators and the innovators' stated reasons for their preferences, we believe this potential bias was substantially mitigated. These limitations notwithstanding, we have made a first attempt to understand farmers’ awareness of and attitudes towards IPR protection, which future studies can build upon and extend.

## 5. Conclusion

This paper aimed at understanding farmer-innovators’ attitudes towards IP protection and open access. The study is based on a sample of 300 farmer-innovators in Kenya, Malawi and Zambia. Results show that more than half of the innovators have no prior information about IPRs. The level of IPR awareness of individual innovators is significantly influenced by their gender, educational attainment, as well as by credit access and proximity to extension service providers. We found evidence that small-scale farmer-innovators are more inclined towards an open access model, as nearly 80% of the innovators in our sample would prefer to share their innovations freely with fellow farmers and stakeholders. Regression results suggest that the main driver behind innovators’ preference for IPR is related to commercial interests. More specifically, we found that the commercialization potential of a farmer innovation is positively correlated with an 8% increase in the probability of preference for IPR protection.

Qualitative comments made by the innovators corroborated the econometric finding that preference for IPR protection is influenced by the desire to be financially compensated for the intellectual efforts and resources expended in generating an innovation. Other reasons cited by the innovators who opted for IPR protection include wanting to be recognized as the original innovator, preventing piracy of farmer-generated innovations and wanting to control the dissemination to ensure that quality is maintained. We also found that preference for the free sharing of innovations is mainly driven by an altruistic desire to improve smallholder livelihoods.

Overall, our findings imply that IPR protection may be of interest in situations where farmer-generated innovations have the potential for commercialization. However, this can be challenging in the countries studied (particularly in Malawi and Zambia), seeing as these countries currently lack the capacity to provide institutional support to farmers interested in IPR protection. Recognizing this challenge and given the finding that most of the innovators would allow their innovations to be shared with the public without IPR restrictions, it would be useful to investigate the potential of alternative forms of compensation, reward and recognition that can support the farmers’ innovation activities. For instance, certain institutions (e.g., SRISTI) have developed partnerships with local communities using regular IPR mechanisms to protect research that is either based on traditional knowledge or made in collaboration with communities by establishing a fund or benefit sharing mechanism to ensure that part of the financial revenue generated by the innovation benefits the original innovators and their communities (Gupta, 2016). Alternatively, contests and prizes can spur innovation and incentivize farmers to focus on projects with verifiable qualities without limiting the spread of knowledge and discouraging follow-on innovations (Clancy and Moschini, 2013; Tambo, 2018). Public recognition of some form can be also used as a prize for communities where the privatization of knowledge is unpalatable or when the innovators would prefer the innovation to be part of the public domain.

## CRediT authorship contribution statement

**Justice A. Tambo:** Conceptualization, Methodology, Software, Formal analysis, Writing - original draft, Writing - review & editing, Visualization, Supervision, Project administration. **Evelyn Baraké:** Data curation, Investigation, Writing - original draft, Writing - review & editing. **Augustin Kouevi:** Visualization, Formal analysis, Investigation, Writing - original draft. **Grace Timanyechi Munthali:** Visualization, Formal analysis, Investigation, Writing - original draft.

## Declaration of competing interest

None.

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