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Productivity and Diversity in Research and Agriculture: Improving the IPR Landscape for Food Security

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PRODUCTIVITY AND DIVERSITY IN RESEARCH AND AGRICULTURE: IMPROVING THE IPR LANDSCAPE FOR FOOD SECURITY

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ABSTRACT

While food security has long been a national or regional burden, the advent of international instruments governing intellectual property rights over conventionally bred plant varieties and genetically modified plants has made the management of food security a global concern. Current intellectual property regimes do not provide clear support for innovations in crop productivity or biodiversity, both of which are implicated in the long term stability of food supply. This Paper examines the intellectual property regimes governing agricultural food stocks with respect to the level of support they provide for three key research programs in the development of crop seeds and plants: genetic modification, conventional commercial breeding, and traditional breeding and seed exchange practices. In the result, current intellectual property regimes are found to provide scant encouragement for biodiversity and a questionable distribution of support across the three research programmes. By way of response, the author proposes a solution through the introduction of a utility model regime that could work in concert with both existing and proposed national intellectual property laws and international instruments, including the new *Trans-Pacific Partnership*. The proposed solution would make possible improvements in the balance of support across the three programs and greatly improve the potential for biodiversity by providing powerful transnational protections of short duration for plant varieties, accelerating the conventional breeding development cycle.

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INTRODUCTION

In his novel *The Windup Girl*,[1] Paolo Bacigalupi shares with us an unsettling vision of the future. The great majority of the world's cultivated food is grown from genetically engineered seeds, invented and controlled by a small number of corporations.[2] Most, if not all, natural varieties have vanished, having succumbed to a combination of economic forces and natural disaster.[3] The genetic modifications in the commercially produced seeds provide resistance to diseases crafted to attack food

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[1] *See generally* PAOLO BACIGALUPI, THE WINDUP GIRL (2009) (describing a future Thailand in a world dominated by GMOs in Bacigalupi's hard science fiction novel).
[2] *See id.*
[3] *See id.*

plants as part of the biowarfare and competition strategies of various state and non-state actors, including, of course, the genetically engineered seed companies themselves.[4] Each season, seed must be replaced with new modified stock, in order to stay ahead of the aggressively mutating synthetic microorganisms.[5]

Like many dystopian fantasies, Bacigalupi's tale provides implied commentary about the fragility of the international order and the toothlessness of international agreements in the absence of such order. Although the international community of his fictional world has not completely disappeared, there does not appear to be any operational concept of food security, nor any notion of a human right to food, in the world he depicts. Nor does there seem to be significant impetus to international enforcement of intellectual property rights by legislative means: the seed companies enforce their rights over their genetically modified materials through private armies and bioterrorism.

This vision is a disturbing one, but we need not turn to fiction to find unsettling possible futures. The world faces an enormous challenge to achieving sustainable food security. In addition to the almost 800 million people who suffer from chronic hunger in the present,[6] the outlook for the next twenty years projects an increase in food demand of 50%.[7] We may couple that finding with projections for increased demands on energy (50% by 2030) and water (30% by 2030)[8] to conclude that, without a significant increase in the productivity of existing arable land that does not depend upon a concomitant increase in water or energy input,[9] a

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[4] *See id.*
[5] *See id.*
[6] *See* FOOD & AGRIC. ORG. OF THE UNITED NATIONS, INT'L FUND FOR AGRIC. DEV., & WORLD FOOD PROGRAMME, THE STATE OF FOOD INSECURITY IN THE WORLD: MEETING THE 2015 INTERNATIONAL HUNGER TARGETS: TAKING STOCK OF UNEVEN PROGRESS 4 (2015), *available at* http://www.fao.org/3/a-i4646e.pdf [https://perma.cc/FTM9-ZP9A].
[7] *See* Rob Bertram, *Innovation and Biodiversity*, PUBLIC INTEREST INTELLECTUAL PROP. ADVISORS (PIIPA) 4 (2013), http://web.archive.org/web/20131116020129/http://piipa.org/files/PIIPA_The%20Role%20of%20Intellectual%20Property%20in%20Food%20Security_Seminar%20Summary.pdf [https://perma.cc/8MHP-WKWE] (seminar slide summary).
[8] *See* Denise Dewar, *The Role of Intellectual Property in Food Security in Developing Countries*, PUBLIC INTEREST INTELLECTUAL PROP. ADVISORS (2013), http://web.archive.org/web/20131116020129/http://piipa.org/files/PIIPA_The%20Role%20of%20Intellectual%20Property%20in%20Food%20Security_Seminar%20Summary.pdf [https://perma.cc/KPZ5-9JFM] (seminar slide summary).
[9] *See* GORDON CONWAY, THE DOUBLY GREEN REVOLUTION: FOOD FOR ALL IN THE TWENTY-FIRST CENTURY (1997) (calling for conservation as well as productivity in a second agricultural revolution).

classic Malthusian crisis[10] may well develop. Indeed, if we hope to achieve the yields we need, we will have to improve upon the current productivity improvement curve; between 1980 and today, we have increased productivity per hectare by only 40% (from 1.8 tonnes/ha to 2.5 tonnes/ha).[11]

Addressing our future food security problems will require innovative thinking on both scientific[12] and legislative[13] fronts. From a policy perspective, we need to identify the contribution made by different crop seed research programs towards the goal of increasing sustainable productivity; we then need to examine the intellectual property rights regimes that govern them, in order to ensure that the law—insofar as it can—supports an optimal level of innovative output in each program.

This Paper will not attempt an exhaustive survey of all possible research programs, formal and informal, that might be considered as having a role to play in food security. Instead, it concentrates on three issues—genetic modification, breeding, and traditional crop improvement practices—that support between them the two food security goals of increasing productivity (through yield and hardiness) and stability of food supply (through biodiversity). This Paper will show how the current IPR regimes in national and international law affect these research programs and proposes changes that may offer a better distribution of support among them.

Given that this Paper began by drawing attention to the unfortunate possibilities of a world in which advanced scientific knowledge about genetic engineering and powerful commercial interests intersect, it may come as a surprise to the reader that this Essay treats the importance of support for genetically modified ("GM") food research as an operating assumption. Despite the risks that GM food technology and the market actors controlling it pose to health and to policy respectively, the potential

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[10] *See* Jeffery D. Sachs, *Are Malthus's Predicted 1798 Food Shortages Coming True?*, SCI. AM. (Sept. 1, 2008), http://www.scientificamerican.com/article/are-malthus-predicted-1798-food-shortages/ [https://perma.cc/TSE6-KA9L].

[11] *See* Dewar, *supra* note 8. There are improvements besides raw productivity increases that could be addressed: increasing arable land and reducing food wastage are two possible ways to increase the food supply without depending on the achievement of new levels of productivity per hectare. Any improvements made here, however, could only be auxiliaries to increases in raw productivity: increasing arable land and reducing waste will not provide a 50% increase in food supply. Moreover, both approaches will likely involve increased use of water (e.g., engineering deserts into arable land through irrigation) or energy (better refrigeration, faster transport of harvests to minimize spoilage).

[12] *See* ISMAIL SERAGELDIN & G. J. PERSLEY, PROMETHEAN SCIENCE: AGRICULTURAL BIOTECHNOLOGY, THE ENVIRONMENT, AND THE POOR 6 (July 7, 2010).

[13] *See* Dewar, *supra* note 8.

benefits are too great, and the policy planning timescales on which we are operating too short, to realistically contemplate banning its development or sale. Genetic modification has already assisted us in achieving significant increases in crop productivity, through the development of crops that are capable of thriving under a broader range of conditions than their natural counterparts: modified to divert more photosynthetic energy to grain rather than leaf or stem, or modified to permit the use of virulent herbicides without harming plant growth.[14] Naturally, we should remain alive to the potential hazards associated with GM foods, transgenic agricultural stocks in particular. The increased crop yields of the sort that are likely to overcome the challenges of the next few decades, however, will almost certainly require further scientific research into transgenic plants.[15]

Innovation in conventional breeding, meanwhile, deserves an equal amount of encouragement. Modern commercial conventional breeding has a lower risk profile[16] for unforeseen consequences than genetic modification, which translates in practice into a lower regulatory burden. Commercial breeding, with suitable incentives, may also offer support for biodiversity—which, as we shall discuss, contributes to stabilization of aggregate crop yields. Any solution that hopes to adequately address food security in the twenty-first century, therefore, will likely involve both conventional methods and genetic engineering; under our current form of economic organization, as we shall see below, this entails supporting each research program through intellectual property rights ("IPRs").

Finally, the traditional practices of farmers who save and exchange seeds, using these seeds to replant but also to breed new varieties, should receive policy stimulus as well. These longstanding practices, operating

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[14] *See* PHILIPPE CULLET, INT'L ENVTL. L. RES. CTR., FOOD SECURITY AND INTELLECTUAL PROPERTY RIGHTS IN DEVELOPING COUNTRIES 4 (2003), *available at* http://www.ielrc.org/content/w0303.pdf [https://perma.cc/DAX7-V6NH]; *see also* Sachin Chaturvedi, *Agricultural Biotechnology and New Trends in IPRs Regime: Challenges Before Developing Countries*, 37 ECON. & POL. WKLY. 1212 (2002); R. DAVID KRYDER ET AL., INT'L SERV. FOR ACQUISITION AGRI-BIOTECH APPLICATIONS, THE INTELLECTUAL AND TECHNICAL PROPERTY COMPONENTS OF PRO-VITAMIN A RICE (GOLDEN RICE™) A PRELIMINARY FREEDOM-TO-OPERATE REVIEW (2000).

[15] *See* Dewar, *supra* note 8. *But see* Jonathon Knight, *Crop Improvement: Dying Breed,* 421 NATURE 568, 570 (2003); Ann Marie Thro & Paul Zankowski, *Classical Plant Breeding Is the Route to Food Security,* 422 NATURE 559, 559 (2003); and Keith Aoki, *Malthus, Mendel, and Monsanto, Intellectual Property and the Law and Politics of Global Food Supply,* 19 J. ENVTL. L. & LITIG. 397, 414 (2004) (arguing that conventional improvement techniques alone can provide the productivity solutions we will need for the future).

[16] A caveat: certain methods in modern commercial breeding invite the conclusion that the risk profile may not be uniformly lower. *See infra* Part I.

on extended timescales, constitute an informal yield improvement and seed biodiversification research program in their own right.

In order to elucidate the interaction of IPR laws and their relationship to the three research programs mentioned, this Paper proposes to make a survey of several salient elements before proceeding to analysis. It begins with a very brief overview of the research methods employed by genetic modification and modern commercial breeding. The discussion then turns to the importance of biodiversity for food security, and the role played by traditional practices in this regard. This will be followed by a synopsis of several national and international legislative instruments that affect IPRs for both plant varieties and transgenic plants, in order to illustrate how food security concerns get cashed out in law.

From the discussion, the following conclusions will be drawn.

Taken in the aggregate, the current international regime has an uncertain relationship to traditional practices at best. To the extent that these practices offer a reserve of genetic diversity in seed stock, they ought to be of interest to legislators; but, the legislative methods used to incentivize research programs that may rapidly produce significant increases in crop yield reveal a distinct tendency to minimize support for these traditions.

Effective improvements, however, can be made by providing stronger IPRs with shorter terms. For a variety of reasons that will be discussed below, this is neither practical nor desirable in the case of transgenic plants; but, it does seem to be a realistic possibility in the case of plant varieties produced through conventional breeding, and may have salutary benefits for both the innovative capacity of commercial breeding R&D cycles and traditional farming practices. The Paper concludes by proposing the use of a legislative framework involving a form of intellectual property protection known as the "utility model," which may improve the distribution of support without falling afoul of existing legislative schemes or international treaties.

As international agreements intended to guide the harmonization of IPRs at a global level become further entrenched, legislative choices made by member states will play a crucial role in the future trajectory of food security. Even with the instruments currently in play, those choices can be sculpted in ways that may provide an effective compromise across the three programs we have mentioned—despite the relative inflexibility that circumstances dictate with respect to genetically modified plants. That our future will be beholden to the development of transgenic crops and the use of commercially bred seed is likely inevitable, and we need to be realistic about the kinds of compromise that will require; but Bacigalupi's unsettling nightmares need not follow.

I. BREEDING AND GENETIC MODIFICATION

A. Conventional Breeding

It bears mentioning from the outset that conventional breeding and genetic modification are in the same business: mixing genes into new functional genotypes, with an eye to encouraging the phenotypic expression of particular traits.[17] Breeders do this in several ways. The primary method is to find plants with interesting traits and attempt to cross-pollinate them with other related plants that have other desirable traits.[18] When the crossing yields a successfully germinating plant, the modern breeder will frequently test the tissue of the result for gene markers, to see whether all the desired genetic traits have crossed over into the child.[19] Such cross-breeding is typically repeated many thousands of times before the desired combination of traits is achieved.[20] The use of genetic markers can add some efficiency to the process by allowing breeders to see whether the desired cocktail of traits is present, without waiting for the seedling tested to come to maturity and display full phenotypic expression of the desired traits; where the combination sought is absent, the breeder can destroy the batch and begin a new round of crossing.[21] However, even where the desired genotypic combination is detected, the breeders must then wait to see whether the traits express correctly.

Modern breeders will also attempt to create interesting traits by inducing mutations. Such research is much less targeted than traditional crossing and conscious selection of desirable traits, as it amounts to "rolling the dice and hoping to get something interesting."[22] From a methodological perspective, this sounds implausible, but the results are

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[17] *See* COMM. ON ENVTL. IMPACTS ASSOCIATED WITH COMMERCIALIZATION OF TRANSGENIC PLANTS, BD. ON AGRIC. & NAT. RES., DIV. ON EARTH & LIFE STUDIES, & NAT'L. RESEARCH COUNCIL, ENVTL. EFFECTS OF TRANSGENIC PLANTS: THE SCOPE AND ADEQUACY OF REGULATION 37 (2002).
[18] *See id.*
[19] *See id.* at 37, 41–42.
[20] *See* Nathanael Johnson, *Genetic Engineering vs. Natural Breeding: What's the difference?*, GRIST (July 16, 2013), http://grist.org/food/genetic-engineering-vs-natural-breeding-whats-the-difference [https://perma.cc/S8HS-RT6N].
[21] *See id.*
[22] *See id.*

sometimes successful.[23] It bears remarking here that, in addition to being a fairly substantial departure from traditional crossing techniques, irradiative methods may actually induce more genetic changes in a plant than genetic engineering.[24]

B. Genetic Modification

In contrast to these approaches, genetic modification appears at first glance to be much more precise. The first step is identification of a gene that expresses a particular trait, followed by isolation of the gene of interest.[25] The gene will be cloned inside a host cell prepared for the purpose, and the copies made are then "packaged."[26] The package may consist of a genetic sequence that includes the gene of interest itself, a promoter and a terminator (to activate and deactivate the gene, respectively), and another gene for a separate, visible trait that can act as a marker for the presence of the package.[27] This phase of genetic engineering is quite precise, and the methods employed reliably produce the intended sequence of traits that form the elements of the package.

The introduction of the gene into the target plant is usually undertaken through one of two methods: biolistic transformation or *agrobacterium*-mediated transformation.[28] Biolistic transformation employs what is colloquially known as a "gene gun" which fires particles coated with gene packages at living plant tissue.[29] Such application of mechanical force will sometimes result in the contents of the gene package being incorporated into cell nuclei through natural cellular

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[23] Calrose 76 rice, for example, was developed from seed deliberately exposed to 25 kR of Cobalt-60 gamma radiation. *See* J.N. Rutger et al., *Registration of 'Calrose 76' rice*, GRAMENE, http://archive.gramene.org/newsletters/varieties/Calrose76.html [https://perma.cc/8HH2-5FLW] (last visited Mar. 27, 2016).
[24] *See* Rita Batista et al., *Microarray Analyses Reveal That Plant Mutagenesis May Induce More Transcriptomic Changes Than Transgene Insertion*, 105 PROC. NAT'L ACAD. SCI. U.S. 3640, 3640 (2008).
[25] *See Pocket K No. 17: Genetic Engineering and GM CROPS*, INT'L SERV. FOR ACQUISITION AGRI-BIOTECH APPLICATIONS (Aug. 2014), http://www.isaaa.org/resources/publications/pocketk/17 [https://perma.cc/2EYX-9BVP] [hereinafter *Pocket K*].
[26] *See id.*
[27] *See How Do You Make a Transgenic Plant?*, TRANSGENIC CROPS (Mar. 11, 2004), http://cls.casa.colostate.edu/transgeniccrops/how.html [https://perma.cc/CVT2-ZSSA].
[28] *See* Caixia Gao & Klaus Nielsen, *Comparison Between Agrobacterium-Mediated and Direct Gene Transfer Using the Gene Gun*, METHODS MOLECULAR BIOLOGY, Jan. 2013, at 3–4.
[29] *See* Johnson, *supra* note 20.

processes.[30] One advantage of this method is that multiple genes may be combined or "stacked" into the same package payload and delivered through a single insertion.[31] The process, however, has been noted to result in the insertion of multiple copies of the gene package as well as integration of incomplete fragments.[32]

The scattershot approach of biolistic insertion stands in sharp contrast to the *agrobacterium* method. *Agrobacterium*-mediated transformation leverages the natural capacity of *agrobacterium tumefaciens* to transfer DNA between itself and plants through the use of gene fragments called plasmids.[33] The gene package is first groomed into a plasmid, and then swapped out for the native *agrobacterium* plasmid; the target plant is then infected with the bacterium, which then transfers the gene package into the nuclei of the plant's cells.[34] This method consistently yields single-site[35] and single-copy[36] gene insertions and has higher transformational efficiency than biolistic insertion.[37] However, the plasmid method does not allow for the stacking of multiple genes, which are needed for the pursuit of sophisticated genetic manipulation strategies.[38] Moreover, the method does not work for all plants. In consequence, despite the greater precision of the *agrobacterium*-mediated method, the biolistic method remains popular and its use widespread.[39]

The methods employed by genetic engineers are indifferent to the actual genetic payload to be inserted. This allows for genetic engineering's most notorious and sensational capacity: the insertion of genes from radically different organisms and the consequent successful phenotypic expression of those genes within the new hosts.[40]

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[30] *See id.*
[31] *See* Gao & Nielsen, *supra* note 28, at 3.
[32] *See* F.D. Meyer & M.J. Giroux, *Section II.2 Wheat*, *in* TRANSGENIC CROPS IV 55, 63 (Eng-Chong Pua & Michael Davey eds., 2007); *see also* Gao & Nielsen, *supra* note 28, at 3–4.
[33] *See* Meyer & Giroux, *supra* note 32, at 62.
[34] *See id.*
[35] *See* Marc De Block & Dirk Debrouwer, *Two T-DNAs Co-transformed into Brassica Napus by a Double Agrobacterium Tumefaciens Infection Are Mainly Integrated at the Same Locus*, 82 THEORETICAL & APPLIED GENETICS 257 (1991); Sylvie De Buck et al., *The DNA Sequences of T-DNA Junctions Suggest That Complex T-DNA Loci Are Formed by a Recombination Process Resembling T-DNA Integration*, 20 PLANT J. 295, 295 (1999).
[36] *See* Gao & Nielsen, *supra* note 28, at 4.
[37] *See* Meyer & Giroux, *supra* note 32, at 63.
[38] *See* Gao & Nielsen, *supra* note 28, at 4.
[39] *See id.*
[40] *See, e.g.*, Richard Hellmich & Kristina Hellmich, *Use and Impact of Bt Maize*, NATURE EDUC. KNOWLEDGE (2012), http://www.nature.com/scitable/knowledge/library/use-and

This is not in itself necessarily alarming. Combined, however, with the known tendency of the biolistic method to introduce multiple copies and fragments of packaged sequences[41] and the pressure to use that method in order to exploit the efficiency of single-shot gene stacking,[42] the net effect in practice is that current genetic engineering strategies for plant improvement employ a set of methods whose possible consequences are not well-understood.[43] The incorporation of desired traits into a plant will sometimes be accompanied by the alteration of other traits;[44] the consequences of those unintended transformations may not be detected until long after the plants have been introduced into the food supply system.[45]

This does not mean such research should not be pursued. Despite being a nascent research program, genetic engineering has already yielded spectacular short-to-medium-term outcomes.[46] Because we lack both a sophisticated understanding of the results of genetic modifications and a data set large enough to provide input for long-term analysis, however, conventional methods still hold attraction owing to their long track record in the field and the relatively conservative character of the changes they introduce. Briefly put: viewed from the combined perspective of

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-impactof-bt-maize-46975413 [https://perma.cc/MP4Q-S9B7] (noting that Bt Maize imports a gene with insecticidal activity from a bacterium and explaining its impact).

[41] *See* Meyer & Giroux, *supra* note 32, at 63.

[42] *See* Gao & Nielsen, *supra* note 28, at 4.

[43] *See* Meyer & Giroux, *supra* note 32, at 61.

[44] A clear example of this is the pleiotropic effect (when one gene influences two or more seemingly unrelated phenotypic traits) observed on plants engineered with the bar gene, which produces resistance to the herbicide glusofinate. One study funded by the Canadian Food Inspection Agency showed that of the genes unique to transgenic plants that differently expressed in reaction to glusofinate exposure, many had no known function. *See* Ashraf Abdeen & Brian Miki, *The Pleiotropic effects of the Bar Gene and Glusofinate on the Arabidopsis Transcriptome*, 7:3 PLANT BIOTECHNOLOGY J. 266, 266 (2009). Unintended effects have also been observed in transgenic plants engineered to overexpress oryzacystatin I, which has insecticidal activity. It has been noted, for example, that the overexpression of this gene affects plant growth systems. *See* Rafael Gutiérrez-Campos et al., *Pleiotropic Effects in Transgenic Tobacco Plants Expressing the Oryzacystatin I Gene* 36:1 HORTICULTURAL SCI. 118, 118–19 (2001).

[45] *See, e.g.*, Harry A. Kuiper et al., *Adequacy of Methods for Testing the Safety of Genetically Modified Foods*, 354 THE LANCET 1315, 1315–16 (1999) (where the authors note that current methods for testing foods concentrate on macro/micro nutrients and known toxins). Since it is known that transgenic plants may express genes in unexpected ways, *see* Meyer & Giroux, *supra* note 32, testing for other elements, such as mRNA fingerprinting, proteomics and secondary metabolite profiling, is desirable. In the absence of such rigorous testing, new toxins or other agents may be unwittingly introduced into the environment or the food supply system.

[46] I consider, in this connection, the advent of Monsanto's Roundup-ready wheat as an important success in the pursuit of increased crop productivity.

experimental method and potential outcome, both research programs have their merits and deserve protection.

II. FOOD SECURITY AND BIODIVERSITY

The first international discussions of food security emphasized quantity and availability of supply.[47] Modern formulations also incorporate other criteria we have come to recognize as germane, such as quality and nutritional value:

> Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.[48]

Despite such nuancing, the underlying goal remains unchanged: to ensure the availability of food and encourage the development of food production systems sufficient to stabilize such availability in the face of rising demand curves.

Achievement of such a goal, as already mentioned, will be unlikely without significant and sustained investment into research concerned with increasing the productivity of food production systems. That research is intended to address the need for adequate quantity; it does not directly address the stability of supply.

Biodiversity is known to have stabilizing effects on the biomass productivity of a given ecosystem.[49] As biodiversity increases, the likelihood that the ecosystem will contain species that possess traits adaptive to environmental changes increases as well.[50] Moreover, the presence of diverse traits *within* a given species can buffer the ecosystem against the loss of still other species, increasing overall resilience.[51] Biodiversity thereby provides a form of insurance against the deleterious effects of change.[52]

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[47] Report of the World Food Conference, Nov. 5–16, 1994 ("availability at all times of adequate world supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices").

[48] *FAO Policy Brief on Food Security*, Issue 2 at 1 (June 2006), http://www.fao.org/forestry/13128-0e6f36f27e0091055bec28ebe830f46b3.pdf [https://perma.cc/473C-N7X3].

[49] *See* Elsa E. Cleland, *Biodiversity and Ecosystem Stability*, NATURE EDUC. KNOWLEDGE 3:10(14) (2011), http://www.nature.com/scitable/knowledge/library/biodiversity-and-ecosystem-stability-17059965 [https://perma.cc/T6KF-GAVN].

[50] *Id.*

[51] *Id.*

[52] Shigeo Yachi & Michael Loreau, *Biodiversity and Ecosystem Functioning in a Fluctuating Environment: The Insurance Hypothesis*, 96 PROC. NAT'L ACAD. SCI. U.S. 1463 (1999); David

It is not difficult to transfer these environmental science insights into the context of crop production. Arable land is spread across many different ecosystems, each with its own climate and disease profile; moreover, the stability of many such systems is eroding as climate change accelerates. Agricultural biodiversity can provide a buffer against changes in these variables; we depend upon sustained levels of agricultural productivity, and biodiversity provides stabilization for such productivity. We can therefore benefit from ensuring diversity in crop production systems, both from the breeding of new varieties and from the exchange of seeds and other propagation materials.

The dangers of monoculture are well-understood but must compete with the pressure from food industry markets that favour product uniformity and its concomitant predictability from both cost and revenue perspectives.[53] The recent history of banana cultivation offers a clear example. The twentieth century saw the demise of the *gros michel* banana, cultivated primarily for consumption in the industrialized nations, and a subsequent worldwide banana shortage.[54] As the plantations bearing the *gros michel* were ravaged by disease, they were supplanted by a new variety: the *cavendish*, which we find in supermarkets worldwide today.[55] Despite the fact that it was clear to the farmers and industrial plantation owners that their crop had been devastated because of their reliance on a single variety, the demand for product uniformity was sufficient to induce the wholesale replacement of the *gros michel* by the *cavendish*;[56] we traded one monoculture for another. History repeats itself. As it now stands, we will almost certainly observe the demise of the *cavendish* variety as an industrial crop by 2020.[57]

Even if monoculture were restricted to bananas alone, it would have a significant impact on global food security. Behind rice, wheat, and maize, bananas and plantains constitute the 4th largest global crop by

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Tilman et al., *Biodiversity and Ecosystem Stability in a Decade-Long Grassland Experiment*, 441 NATURE 629 (2006); Yongfei Bai et al., *Ecosystem Stability and Compensatory Effects in the Inner Mongolia Grassland,* 431 NATURE 181 (2004); D.W. Schindler, *Experimental Perturbations of Whole Lakes as Tests of Hypotheses Concerning Ecosystem Structure and Function*, 57 OIKOS 25 (1990).

[53] *See* Dan Koeppel, *Can This Fruit Be Saved?*, POPULAR SCI. (June 19, 2005), http://www.popsci.com/scitech/article/2008-06/can-fruit-be-saved [https://perma.cc/Y4QR-CSF2].

[54] *Id.*

[55] *See* Phoebe Sedgman, *There Might Be No Saving The World's Top Banana*, BLOOMBERG BUS. (June 4, 2015), http://www.bloomberg.com/news/articles/2015-06-04/banana-killer-on-the-march-fuels-risk-of-fruit-s-next-extinction [https://perma.cc/Q436-AV5L].

[56] *Id.*

[57] *Id.*

cash value[58] and a staple part of the diet of hundreds of millions worldwide.[59] In some areas, widely cultivated staple varieties are succumbing to a wilt to which they have no resistance.[60] Many varieties of banana are still cultivated in small quantities, however, and this reserve of biodiversity is being used to breed new cultivars that are resistant to current widespread diseases.[61] Even if biodiversity cannot be achieved at industrial scales because of market pressures, future productivity may well depend upon our ensuring at least *some* level of biodiversity for each given agricultural region and crop.

Traditionally, the diversification and breeding of cultivars was the domain of farmers themselves.[62] The distinction between farmer and commercial breeder that modern legislation contemplates did not exist. The role of farmers in safeguarding biodiversity is widely recognized; the *Food and Agriculture Organization* has acknowledged "the past, present and future contribution of farmers . . . in conserving, improving, and making available plant genetic resources."[63] The *Convention on Biological Diversity* has also recognized that farmers "play a key role as custodians and managers of agricultural biodiversity."[64] The European Union ("EU") has even indicated its concern over the loss of traditional farming methods as creating a threat both to "biodiversity on farmland" as well as to natural and semi-natural habitats that traditional farming has safeguarded in the past.[65]

It may be that modern farmers invest much less time in breeding than before, but they still engage in seed exchange, another potential route to increasing biodiversity.[66] Seed exchange practices are often tied up

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[58] Bob Holmes, *Go Bananas*, 2913 NEW SCIENTIST 39, 39–41 (April 2013).
[59] *Banana and Plantain*, CONSULTATIVE GROUP ON INT'L AGRIC. RESEARCH, http://www.cgiar.org/our-research/crop-factsheets/bananas/ [https://perma.cc/SWV7-Z9Q7].
[60] Xan Rice, *Ugandan Scientists Grow GM Banana as Disease Threatens Country's Staple Food*, THE GUARDIAN (Mar. 9, 2011), http://www.theguardian.com/world/2011/mar/09/gm-banana-crop-disease-uganda [https://perma.cc/LF34-A63K].
[61] Holmes, *supra* note 58.
[62] *See* Hans Hurnij et al., *Agriculture at the Crossroads*, INT'L ASSESSMENT FOR AGRIC. KNOWLEDGE, SCI. & TECH. FOR DEV. (2009), http://www.unep.org/dewa/agassessment/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Global%20Report%20(English).pdf [https://perma.cc/ENX2-5B4T].
[63] S. TREATY DOC. NO. 100-19.
[64] *Why is it Important?*, CONVENTION ON BIODIVERSITY, https://www.cbd.int/agro/importance.shtml [https://perma.cc/PJ76-EF5G] (last visited Mar. 27, 2016).
[65] *See Agriculture and Biodiversity*, EUROPEAN COMM'N (2013), http://ec.europa.eu/agriculture/envir/biodiv/ [https://perma.cc/2SR6-VYYF].
[66] *See* Marco Pautasso et al., *Seed Exchange Networks for Agrobiodiversity Conservation: A Review*, 33 AGRONOMY SUSTAINABLE DEV. 151, 151–52 (2013); Laura Calvet-Mir et al.,

with a variety of social norms and other motivations totally unrelated to improved yield, biodiversity, or conservation goals.[67] Because the practice is extremely widespread in traditional farming communities, particularly in the developing world, it constitutes an enormous—albeit informal—continuously operating research program in agricultural biodiversity whose importance to global food security should not be underestimated.

In the developed world, there has been widespread adoption of monocultural production,[68] accompanied by a decline in seed exchange and a migration towards seed supply through commercial breeders.[69] Current statutory instruments in the developed world have had an effect on seed exchange, and insofar as seed exchange is a contributing factor to sustaining crop biodiversity, it is clear that current IPR regimes exert at least some pressure here.[70]

For all the recognition of the contribution of traditional farming practices to biodiversity, however, it is not clear that changes to or restrictions on such traditional practices will necessarily lead to a catastrophic decline in biodiversity. A well-modulated statutory regime may be able to sustain those practices and, perhaps, encourage other avenues of biodiversity development.

We may conclude this section with the following observations. Population pressures require increased crop yields. Genetic engineering and modern commercial breeding between them offer the most realistic possibility of generating new, safe food crops with increased yields. The result of this research, when successful, usually results in the widespread distribution of a small number of highly desirable varieties, undercutting agricultural biodiversity. Yet biodiversity provides insurance on multiple levels, stabilizing crop yields in the face of disease, local environmental changes, and the unpredictable broader consequences of climate change. Of the three research programs we are exploring in this Paper, traditional practices appear to contribute a good deal to biodiversity. As such, so long as a substitute program with similar benefits is not available, these practices deserve some measure of support along with conventional

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Seed Exchange as an Agrobiodiversity Conservation Mechanism: A Case Study in Vall Fosca, Catalan Pyrenees, Iberian Peninsula, 17 ECOLOGY & SOCIETY (2012), *available at* http://www.ecologyandsociety.org/vol17/iss1/art29/ [https://perma.cc/7GV2-VTHG].

[67] *See* Pautasso et al., *supra* note 66, at 156.

[68] *Id.* at 157.

[69] *Id.*

[70] Joreon van Wijk, *How Does Stronger Protection of Intellectual Property Rights Affect Seed Supply? Early Evidence of Impact*, OVERSEAS DEV. INST. (1996), http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/2965.pdf [https://perma.cc/646P-2VSB].

breeding and transgenic research. In the next two sections, we will consider the extent to which the current IPR landscape supports these three programs.

III. INTELLECTUAL PROPERTY RIGHTS: INVENTION, INNOVATION, AND CAPITAL-INTENSIVE RESEARCH

A comprehensive survey of the wide variety of motivations for IPR regimes is beyond the scope of this Essay. A few remarks, however, will help illuminate the likely policy connection between IPRs and modern food production.

The dominant contemporary narrative is that IPRs provide an incentive to create.[71] In the case of patents, the underlying motivation is the practical benefit that can arise from the kind of creation that patents protect: useful invention.[72] The protection offered is part of a bargain: in exchange for an exclusive right of exploitation, the inventor discloses his invention for public inspection and understanding, allowing others to consider its utility in other contexts, and conduct research towards those ends, even while the patent is in force.[73] In this way, so the dominant narrative goes, the patent system strikes a balance between providing incentives to create and ensuring that new knowledge is made public, such that it can nourish the next generation of inventions.[74]

As seductive as it may be, there are reasons to doubt the extent to which this narrative fully explains the current IPR system. It does not, for example, explain the length of patent grants as twenty years, as opposed to three, five, or fifty, nor does it explain why a uniform term applies to all patents regardless of the field in which they are granted.[75] Moreover, the narrative does not make clear why we should assume that this method of providing pecuniary reward for the creative activity of invention efficiently allocates resources. It is true that the possibility of such reward may encourage those with sufficient talent to channel their energies towards invention, but it will also divert the resources of those

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[71] *See* U.S. CONST. art. I § 8, cl. 8. ("[T]he Progress of Science and useful Arts.")
[72] *Id.* With respect to copyright and trademark, the motivations are more nebulous but still connected to the public good: "to stimulate artistic creativity for the general public good." *See* Twentieth Century Music Corp v. Aiken, 422 U.S. 151, 156 (1975).
[73] *See generally Twentieth Century Music Corp*, 422 U.S. 151 (1975).
[74] *See generally id.*
[75] *Id.* (describing the desire to reward the producer with a fair gain while keeping in mind the ultimate goal of stimulating creativity).

without such creative talents who dream of striking it rich, when their time and effort could be put to better use elsewhere.

One obvious answer is that our IPR regime is more directly concerned with supporting innovation within the system of private capital investment that we have adopted as a model for economic growth. Some fields require significant capital input for infrastructure and the pooling of talent in order to innovate with any degree of consistency. Insofar as innovation in a particular sector requires concentration of capital that the state is unwilling to take out of tax revenues, there must be incentives for private investment. In such cases, the narrative of IPRs as incentives makes better sense.

Biotechnology research, for example, is well served by the current regime. Pharmaceutical development, stem cell and regenerative medicine research, and genetically modified food source development all require significant capital outlays up front in order to fund both basic and translational research.[76]

The same is true, to a lesser extent, of the activities of commercial breeders. Conventional breeding is an activity that can be undertaken without sophisticated equipment or deeply specialized knowledge; traditionally, farmers have provided a source of new varieties of plants through their own informal breeding experiments.[77] Competing in a commercial breeding market, however, requires sophisticated generation techniques (e.g., irradiation), diagnostic methods (e.g., gene markers), and formal training.[78] As such, commercial breeding requires significant capital outlays and could thereby benefit from an IPR incentive scheme as well.

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[76] *See* Neal Masia, *Focus on Intellectual Property Rights, The Cost of Developing a New Drug*, U.S. Dep't of State (Apr. 23, 2008), http://iipdigital.usembassy.gov/st/english/publication/2008/04/20080429230904myleen0.5233981.html#axzz41WKSNCFC [https://perma.cc/36DQ-MWCQ]; *see also* Don Gibbons, *Stem Cell Stories that Caught Our Eye; Drug Screening, Aging Stem Cells in Brain Repair and Blood Diseases*, THE STEM CELLAR, CIRM (March 13, 2015), http://blog.cirm.ca.gov/2015/03/13/stem-cell-stories-that-caught-our-eye-drug-screening-aging-stem-cells-in-brain-repair-and-blood-diseases/ [https://perma.cc/J9D2-7E2H]; Chantal Pohl Nielsen et al.,*Trade in Genetically Modified Food: A Survey of Empirical Studies,* Int'l Food Policy Research Inst., (Nov. 2002), http://ageconsearch.umn.edu/bitstream/16317/1/tm020106.pdf [https://perma.cc/W3HL-UAAR].

[77] Norman E. Borlaug, *Contributions of Conventional Plant Breeding to Food Production*, 219 SCIENCE 689 (Feb. 11, 1983), *available at* http://libcatalog.cimmyt.org/download/borlaug/719.pdf [https://perma.cc/93KD-SJL5].

[78] *See generally* Satoru Ishikawa et al., *Ion-Beam Irradiation, Gene Identification, and Marker-Assisted Breeding in the Development of Low Cadmium Rice*, 109 NAT'L ACAD. OF SCI. 47 (2012), *available at* http://www.pnas.org/content/109/47/19166.full [https://perma.cc/G57Y-JKJG].

The question at issue is whether the national and international instruments we have now yield effective protection for, and sustain innovation in, the research programs that support food security. In the next section, we will explore the international conventions and enabling statutes with this question in mind.

IV. THE INTERNATIONAL IPR LANDSCAPE IN AGRICULTURE

Patent laws are not the only protections governing IPRs in plants at both the national and the international level; there are also statutes and international instruments providing protection for *plant varieties*.[79]

These schemes differ from patent regimes in important ways. Plant variety protections are much less costly to obtain than patents. Applications for such protections, for example, need not demonstrate any kind of potential for utility or industrial application;[80] nor need they fulfil the extensive obligations of description and disclosure required for patents.[81] Perhaps most importantly, there are exemptions to these protections that relate to food security.[82] Examining the relevant legislative instruments and their interaction with patent law will help make prominent the ways in which food security concerns express themselves through IPRs.

A. Plant Variety Protection

1. Breeders' Rights and Their Exemptions

Available to plant breeders in many countries, plant variety protections ("PVPs") provide a form of protection for the fruits of crop plant R&D. Although the International Union for the Protection of New Varieties of Plants has many members (all of whom are signatories to the *UPOV* convention on plant varieties),[83] this section will focus on the

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[79] *See generally* Mark D. Janis & Jay P. Kesan, *U.S. Plant Variety Protection: Sound and Fury. . .?,* 39 HOUS. L. REV. 727 (2002).

[80] Although the uniformity and stability requirements allude to commercial acceptability in the various PVP acts described in this section, actual utility is not necessary for a certificate to be granted. Compare this with the regime governing patents: 35 U.S.C. §§ 101–103, and the European Patent Convention arts. 54, 56, and 57.

[81] Janis & Kesan, *supra* note 79, at 730.

[82] *See generally* Agreement on Trade-Related Aspects of Intellectual Property Rights art. 8, Jan. 1, 1995, 1869 U.N.T.S. 300.

[83] *See Members of the International Union for the Protection of New Varieties of Plants*, UPOV (2014), http://www.upov.int/export/sites/upov/members/en/pdf/pub423.pdf [https://

contrasting approaches to PVPs in the European Union and the United States, as this comparison will highlight the potential for a multilayered approach to IPRs in plant varieties and the effects relevant to our discussion of food security.

Article 1 of *UPOV* provides the following definition of plant variety:

> "variety" means a plant grouping within a single botanical taxon of the lowest known rank, which grouping, irrespective of whether the conditions for the grant of a breeder's right are fully met, can be:
>
> —defined by the expression of the characteristics resulting from a given genotype or combination of genotypes,
>
> —distinguished from any other plant grouping by the expression of at least one of the said characteristics and
>
> —considered as a unit with regard to its suitability for being propagated unchanged . . .[84]

As signatories to *UPOV*, the EU and the United States have each established similar laws that specifically provide for the governance of PVPs.[85] The United States has provided for twenty-year terms of protection for plants,[86] and the EU has opted for twenty-five.[87] Both will grant such protection upon demonstration of distinctiveness, uniformity, stability,

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perma.cc/HU3R-C7YQ]; International Convention for the Protection of New Varieties of Plants, 815 U.N.T.S. 11609 (1968) [hereinafter *UPOV*]. This convention has been revised several times, in 1961, 1972, 1978, and 1991. *See also UPOV*, at arts 5–6. Not all signatories are bound to the latest revision, which extended the terms of protection and formalized the requirements for grant of protection, including the introduction of novelty as a requirement. *UPOV* also introduced the idea of an *essentially derived variety*, which was then adopted into legislation in the United States and the European Union. The United States and European Union are both bound to the latest revision.

[84] *See UPOV*, *supra* note 83, at art. 1(vi).

[85] *See* EC*, Council Regulation (EC) 2100/94 of 27 July 1994* (on community plant variety rights) (amended by council regulation *(EC) 2506/95 of 25 October 1995*; [1994] OJ L 227/1 [hereinafter *ECPVR*]; and the *Plant Variety Protection Act*, 7 U.S.C. § 2321 (1970) [hereinafter *PVPA*]). It must be borne in mind that the *PVPA* was brought into alignment with the provisions of *UPOV* in 1994.

[86] *See PVPA*, *supra* note 85, at § 83(b)(1).

[87] *See ECPVR*, *supra* note 85, at § 19(1).

and novelty,[88] and extend that protection beyond the protected variety to any "essentially derived" variety.[89] The grants may be given whether the variety applied for was deliberately pursued or discovered and subsequently developed,[90] and give the grant holder exclusive rights over the production, conditioning, sale, import, and export of both seeds and the fruits of harvest.[91]

Although they appear at first glance to offer protections similar to those of patents, these enabling statutes and *UPOV* provide several exemptions, all of which might be regarded as being concerned with food security.

The first is an option for states to restrict breeders' rights in the public interest. *UPOV*'s laconic expression[92] of this option stands in contrast to the elaborations articulated in the *ECPVR*[93] and the *PVPA*,[94] but the thrust is similar. Although the United States and the EU allow the state to trench on breeders' rights to different degrees, if it is in the public interest, the government may override the breeder's right to exclude others as long as equitable remuneration is provided to the breeder (for example, through compulsory licensing).[95]

A second exemption, which is compulsory,[96] protects the right of breeders to use a protected variety for the purpose of breeding new varieties: a PVP version of the research exemption that sometimes accompanies the legislation for patent regimes.[97]

A third exemption protects the right of farmers to save seeds for the propagation of crops on their own land, whether for their own purposes or for sale as a crop. Sale or exchange of seed for the purpose of propagation, however, requires authorization from the breeder.[98] In the EU, this exemption is directed at small farms; seed saving farmers must

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[88] *Id.* at arts. 7–10; *PVPA*, *supra* note 85, at § 42(a).
[89] *See ECPVR*, *supra* note 85, arts. 13(5)–(6); *PVPA*, *supra* note 85, at § 41(a).
[90] *See ECPVR*, *supra* note 85, at art. 11(1); *PVPA*, *supra* note 85, at § 97(2) (Definitions); *UPOV*, *supra* note 83, at art. 1(iv).
[91] *See ECPVR*, *supra* note 85, art 13(2); *see also PVPA*, *supra* note 85, at § 111(a).
[92] *See UPOV*, *supra* note 83, at art. 17.
[93] *See ECPVR*, *supra* note 85, at art. 29.
[94] *See PVPA*, *supra* note 85, at § 44.
[95] *See ECPVR*, *supra* note 85; *see also PVPA*, *supra* note 85.
[96] *See UPOV*, *supra* note 83, at art. 15(1).
[97] *See PVPA*, *supra* note 85, at § 114; ECPVR, *supra* note 85, at art. 15(b)–(c).
[98] *See UPOV*, *supra* note 83, at art. 15; *PVPA*, *supra* note 85, at § 113; *ECPVR*, *supra* note 85, at art. 14. Prior to 1994, the *PVPA* included a sale exemption for farmers, which exemption was clarified and defined by the U.S. Supreme Court in *Asgrow Seed Co. v. Winterboer*, 513 U.S. 179 (1995). That protection was eliminated in 1994 when the *PVPA* was amended in order to align it with the 1991 version of the *UPOV*.

provide "equitable remuneration" to the breeder if the annual production of their farm exceeds ninety-two tonnes of cereals.[99] Although this farmer's exemption is now enshrined in the *PVPA* and the *ECPVR*, *UPOV* leaves it as optional.[100]

2. Traditional Practices: Limited Protection

The farmer's exemption in *UPOV*, the *PVPA* and the *ECPVR* can be read as having been put into place in order to safeguard traditional seed saving practices, and, by extension, agricultural production.[101] But by making protection of breeder's rights mandatory while simultaneously curtailing the traditional practices of farming communities and making the agreement's residual protection of those same practices merely optional, *UPOV* appears skewed towards protecting the activities of breeders over those of farmers. This has drawn criticism from some quarters.[102]

In this connection, these acts have also been criticized for essentially turning what was originally a fairly limited right for breeders to control the commercial sale of varieties they had developed into a much more extensive form of appropriation akin to the protections afforded through patents.[103] It is likely that part of the pressure to extend the rights of breeders under *UPOV* and the national legislation adopting its provisions may have derived from conventional seed producers concerned about the protections afforded to companies such as Monsanto, whose modifications to seed were covered by patent.[104] The introduction of protection for essentially derived varieties in the 1991 revision of *UPOV*, for example,

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[99] *See ECPVR*, *supra* note 85, at art. 14(3); *UPOV*, *supra* note 83, at art. 15(2). The *UPOV* appears to leave the matter of remuneration open, or at least open to interpretation, when it mentions protection of the breeder's legitimate interests in this connection. *See UPOV, supra* note 83, art. 15(2). The United States appears to have interpreted the *UPOV* as permitting no remuneration, as the *PVPA* seems to leave seed-saving practices unrestricted.
[100] *See UPOV*, *supra* note 83, art. 15(2).
[101] *ECPVR*, *supra* note 85, art. 14.
[102] *See* Alvaro Toledo, *Saving the Seed: Europe's Challenge*, GRAIN (Apr. 25, 2002), http://www.grain.org/article/entries/224-saving-the-seed-europe-s-challenge [https://perma.cc/RT45-GS9J].
[103] Silechi Bedasie, *The Possible Overlap Between Plant Variety Protection And Patent: Approaches in Africa with Particular Reference to South Africa and Ethiopia*, 1 Haramaya L. Rev. 125, 131 (2012) (describing the "absence of a clear delineation between the scopes of the relevant laws.").
[104] *See The End of Farm-Saved Seed? Industry's Wish List for the Next Revision of UPOV*, GRAIN (Feb. 16, 2007) [hereinafter *The End of Farm-Saved Seed?*], http://www.grain.org/article/entries/58-the-end-of-farm-saved-seed-industry-s-wish-list-for-the-next-revision-of-upov [https://perma.cc/GK4T-M435].

may have been motivated by a desire to prevent biotech developers from claiming control over a variety simply by inserting a new gene into the propagating material.[105]

That does not explain, however, why breeder's rights seem to take precedence over the protection of traditional farming practices such as seed exchange. That question can be answered by understanding that one general function of the various IPR regimes with respect to the different research programs is to spread risk.

3. Spreading Risk

As mentioned above, the dominant narrative of IPRs assumes that providing limited monopolies for the fruits of research will create incentive for continued innovation in these areas.[106] This rationale seems especially well-suited to those areas of research which require significant capital investments or carry significant risk, such as genetic modification.

Less clearly motivated is the fairly powerful, patent-like protection given to conventional breeders through instruments that follow the model of *UPOV*. Commercial plant breeding is indeed expensive, but it is expensive in part because of the long timescales on which it operates,[107] relative to the timescales needed for modification through genetic engineering.[108] This leads to a puzzle: by providing protection to conventional plant breeding efforts, legislators are effectively encouraging market allocation of resources towards a research program that is less efficient than another with similar research targets (i.e., increasing crop yield).

One explanation for such support is that the protection of the interests of conventional breeders serves a risk-spreading function.[109] Recall the discussion of Section I concerning the risk profiles associated with each methodological approach to improving crop productivity.[110]

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[105] *Id.*
[106] *See generally* Twentieth Century Music Corp v. Aiken, 422 U.S. 151 (1975).
[107] *See The UPOV System of Plant Variety Protection*, INT'L UNION FOR PROT. NEW VARIETIES PLANTS (2011), http://www.upov.int/about/en/upov_system.html [https://perma.cc/W5YF-4NN9].
[108] *See Pocket K*, *supra* note 25.
[109] *See generally UPOV*, *supra* note 83; *cf. Pocket K*, *supra* note 25 (comparing the risks and benefits of traditional breeding and genetic modification).
[110] *See generally* Garry Peterson et al., *The Risks and Benefits of Genetically Modified Crops: A Multidisciplinary Perspective*, ECOLOGY & SOC'Y (Mar. 27, 2000), http://www.ecologyandsociety.org/vol4/iss1/art13/#AssessingTheRisksAndBenefitsOfGmCrops [https://perma.cc/793P-Q5XP].

While genetic engineering provides, by current estimates, the most likely path to staying ahead of the Malthusian curve, it is a path fraught with uncertainty.[111] Modern commercial breeding methods do involve some radical methods for inducing mutations.[112] However, even radiation-induced mutation of a natural plant genome is more likely to produce incremental variation[113] than the kind of transformative leap that introduction of a gene from another species—or even another kingdom—makes possible.[114] Since the long-term effects of genetic engineering on crop plants are not known, it makes sense to cultivate legislative protection for a parallel system: one that has significant drawbacks affecting its efficiency, but whose long track record and incremental methods offer a relatively high degree of comfort.[115]

By the same token, the exemptions granted to farmers may be regarded as providing some protection for that informal research program, in order to spread the risk even further. If modern commercial practice pushes the envelope of conventional breeding through irradiative techniques, farmers cross-pollinating crop plants on their fields employ no such methods; it is the most conservative of the three research programs under consideration. The weakness of those exemptions, however, signals the relative importance of such traditional practices in the eyes of legislators.

Indeed, the relative strength of the different protections—patent, PVP, and farmer exemptions—can be viewed as marking the relative value that legislators place on the three programs in general. If there are any trends to be spotted here, it bears mentioning that *UPOV* has progressively strengthened its protections for plant varieties through its several iterations.[116] While some of that strengthening might be traceable to a breeder lobby interested in shielding its rent collection mechanisms, in

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[111] M. Solem et al., *Malthusian Theory of Population*, AAG CENTER FOR GLOBAL GEOGRAPHY EDUC. (Sept. 18, 2011), http://cgge.aag.org/PopulationandNaturalResources1e/CF_PopNatRes_Jan10/CF_PopNatRes_Jan108.html [https://perma.cc/QLL4-AZX7].
[112] *See* Peterson et al., *supra* note 110.
[113] *See* Johnson, *supra* note 20.
[114] *See* Nancy Moran & Tyler Jarvik, *Lateral Transfer of Genes from Fungi Underlies Carotenoid Production in Aphids*, 328 SCIENCE 624, 624–27 (2010), *available at* http://science.sciencemag.org/content/328/5978/624 [https://perma.cc/C7K5-VBYY] (noting that the concern here is with the unpredictable effects of joining genes from radically different organisms, not whether such joining is "natural" or "unnatural," while interspecies gene transfer is itself a natural phenomenon).
[115] *See* Batista et al., *supra* note 24 (discussing that farmers cross-pollinating crop plants on their fields employ no such methods).
[116] *See The End of Farm-Saved Seed?*, *supra* note 104.

light of the discussion above, it might be said that it also represents an increasing interest on the part of legislators to spread risk by encouraging investment in commercial breeding.[117]

B. Patent Protections for Plant Varieties

The risk-spreading rationale discussed above can be extended to help explain the differential approach between the United States and the EU with respect to patenting plant varieties.

1. United States

The United States permits patenting of plant varieties.[118] The scope of patent protection for plants is just as long as that provided for in the *PVPA*.[119] Where the *PVPA* covers only sexually reproducing plants and tubers[120] and maintains a focus on propagating and harvested material, patents can be granted for plants or parts of plants including seeds and pollen, as well as for methods used to produce the varieties.

For those varietal forms already covered by the *PVPA*, patenting provides stronger protection.[121] Although the original understanding of the *PVPA,* in relation to the *Patent Act*, may have been that the two offered mutually exclusive protective regimes, the possibility of applying for both a *PVPA* certificate and a utility patent arose in the wake of the decision in *Diamond v. Chakrabarty*[122] and was conclusively confirmed in *J.E.M. AG Supply, Inc. v. Pioneer Hi-Bred International, Inc.*[123]

Perhaps most importantly for our purposes, the *Patent Act* contains none of the exemptions for farmers or breeders that the *PVPA* articulates. Although there are statutory research exemptions in the *Patent Act*,[124] these have not been construed as offering any protection for breeding

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[117] *Id.*

[118] *General Information About 35 U.S.C. 161 Plant Patents*, U.S. PATENT & TRADEMARK OFFICE, http://www.uspto.gov/patents-getting-started/patent-basics/types-patent-applications/general-information-about-35-usc-161 [https://perma.cc/XV9W-4FWX] (last visited Mar. 27, 2016).

[119] *Id.*

[120] *See* Plant Variety Protection Act, 7 U.S.C. § 2401 (1970).

[121] *See The End of the Farm-Saved Seed?*, *supra* note 104.

[122] Diamond v. Chakrabarty, 447 U.S. 303, 319–22 (1980).

[123] J.E.M. AG Supply, Inc. v. Pioneer Hi-Bred International, Inc., 534 U.S. 124, 145–47 (2001).

[124] *See* Merck KGAA v. Integra Lifesciences I, Ltd., 545 U.S. 193, 205–08 (2005) (explaining the research exemptions under 35 U.S.C. § 271(e)(1)).

research.[125] Moreover, there is no public interest exemption and no coverage whatsoever for the traditional seed-saving or exchange practices of farmers.[126] In consequence, if a patent is held on a plant variety, the exemptions of the *PVPA* do not apply—whether or not a *PVPA* certificate is also held on that same variety.

2. EU

In sharp contrast to the American model, plant varieties are expressly denied patent protection under the *European Patent Convention*:

> 53. European patents shall not be granted in respect of:
>
> . . .
>
> (b) plant or animal varieties or essentially biological processes for the production of plants or animals; this provision does not apply to microbiological processes or the products thereof.[127]

The reference to "essentially biological processes" in the context of the *EPC* is intended to exclude from patentability the process of "crossing or selection,"[128] or in other words, conventional breeding processes. These exclusions are replicated in the context of the EU's *Biotechnology Directive* at article 4(1)(a) and (b);[129] the same directive, however, provides that isolated plant biological materials and plant-related technologies are patentable:

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[125] *See* Chris Holman, *District Court Rejects Argument that Hatch-Waxman Safe Harbor Applies to Genetically Modified Crops*, HOLMAN'S BIOTECH IP BLOG (Nov. 29, 2012), http://holmansbiotechipblog.blogspot.ca/2012/11/district-court-rejects-argument-that.html [https://perma.cc/MT78-YVJH] (explaining the holding that the patented genetic material used in research counted as a "food additive" and thereby fell within the scope of 35 U.S.C. 271(e)(1)).

[126] 35 U.S.C. § 271(e)(1) (2010) (outlining the patent exemptions in the code).

[127] Convention on the Grant of European Patents (European Patent Convention) art. 53(b), Oct. 5, 1973, 1065 U.N.T.S. 199 [hereinafter EPC].

[128] Directive 98/44/EC of the European Parliament and of the Council of 6 July 1998 on the Legal Protection of Biotechnological Inventions, art. 2, 1998 O.J. (L 213/13) [hereinafter *Biotechnology Directive*].

[129] *Id.* at art. 4.

> Article 3
>
> . . .
>
> 2. Biological material which is isolated from its natural environment or produced by means of a technical process may be the subject of an invention even if it previously occurred in nature.
>
> . . .
>
> Article 4
>
> . . .
>
> 2. Inventions which concern plants or animals shall be patentable if the technical feasibility of the invention is not confined to a particular plant or animal variety.[130]

By providing such protections, the EU allows for patenting of discoveries relating to genetic modification: an isolated gene, for example, may be patented (for a particular purpose), and inserted into different plant varieties in order to encourage expression of a desired trait.[131]

3. Accounting for Asymmetries

The asymmetry between the protective regimes in the EU and the United States can be connected to regional history and the effect of such history on the evaluation of risk.

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[130] *Id.* at art. 3(2), 4(2).

[131] It bears mentioning that the *Biotechnology Directive* at article 4(2) appears to leave open the possibility of patenting varieties, because the introduction of such a patented gene into a plant or into plant propagating material will effectively extend patent protection to the genetically modified organism. The European Patent Office addressed this in their decision regarding *Transgenic Plant / Novartis II*. The upshot of the decision was that claiming a patent over a transgenic plant was not a claim upon the genetics of the plant as a whole: the claimed transgenic plants were defined by characteristics which were expressions of the foreign genes. *See* Michael Blakeney, *Patenting of Plant Varieties and Plant Breeding Methods,* 63 J. EXPERIMENTAL BOTANY 1069, 1070–71 (2012). Note however that the patent was directed at the genes, not their expression (breeding a derivative variety of plant that contained the gene but had suppressed its expression would still be infringing). Because several plants could be defined in the same way, the claim was not for a plant variety (nor several plant varieties).

The EU's careful exclusion of plant varieties from the strong protections afforded patents may be a function of Europe's experiences in the twentieth century. From the time of its early origins as an economic cooperation zone, the EU has maintained a longstanding preoccupation with food security as well as political and economic stability.[132] It addressed these concerns, in part, with legal and economic institutional structures designed to lower the risk of disruption in food supply. Large subsidies flowing through the EU's Common Agricultural Policy, for example, guaranteed food surpluses and low prices.[133]

It might be argued that a corollary of this sensitivity to food security is a legislative tendency to encourage the spread of investment into crop improvement R&D across traditional methods as well as the sophisticated methods of commercial breeding and genetic engineering. The legislative fabric of PVPs and patents in the EU shelters, through its exemptions, is a residue of traditional practices such as seed-saving and farmer-initiated private breeding.[134] That these protections exist, however weak they may be, maximizes the spread of risk and thereby aligns with the EU's generally risk-averse approach to food security.

The United States, which has never faced any significant food security issues, appears to take a more sanguine view.[135] By laying the foundations for patent protection of plant varieties in legislation and jurisprudence, its legislative regimes provide more scope for locking down the experimental use of plant varieties at the expense of traditional practices, narrowing support to research programs with greater efficiency than traditional practices but with higher risk profiles as well.[136]

While the United States provides for some statutory exemptions to the protections provided by the *Patent Act* (aimed at products subject to regulation by the FDA),[137] and there is a residual, extremely narrow common-law research exemption for curious amateurs, there are no

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[132] *Common Agricultural Policy (CAP)*, EUROPEAN CROP PROT., http://www.ecpa.eu/information-page/agriculture-today/common-agricultural-policy-cap [https://perma.cc/GLE5-H58X] (last visited Mar. 27, 2016).
[133] *Id.*
[134] At least with their own seeds or seeds they have purchased legitimately under the terms of the *ECPVR*. Council Regulation (EC) No 2100/94 of 27 July 1994 on Community Plant Variety Rights, O.J. (L 227) 1, 2, 8.
[135] David Bennet, *U.S. Seed Law History: a Primer*, DELTA FARM PRESS (Mar. 2, 2006), http://deltafarmpress.com/us-seed-law-history-primer [https://perma.cc/KK3H-45NQ].
[136] *Id.*
[137] *See generally* 35 U.S.C. § 271(e)(1) (2010) (outlining the patent exemptions in the code).

exemptions directed at commercial research and development of plant varieties.[138] A plant breeder who chooses to patent his/her variety can exclude others from its use, not only in rival commercial research programs,[139] but for any breeding use that is directed at a commercial purpose. This could include local breeding experiments conducted by farmers on their own farms, which experiments have traditionally been undertaken not only to improve crop yields but also in order to produce seed that could be sold at seed exchanges.

In effectively abandoning support for these practices, the United States is displaying a greater appetite for risk than the EU. The United States is still spreading risk to some extent, however, by encouraging allocation of resources across the two higher risk/higher reward approaches furnished by commercial breeding and genetic engineering.

C. The Agreement on Trade-Related Aspects of Intellectual Property Rights

Apart from *UPOV*, its statutory counterparts, and national patent legislation, there is one other significant instrument governing IPRs in plants and therefore influencing the several research programs we have been discussing: the *Agreement on Trade-Related Aspects of Intellectual Property Rights* (*TRIPs*).[140]

For our purposes, the importance of *TRIPs* arises from the flexibilities it allows with respect to the implementation of PVPs and its endorsement of patent protection for transgenics. Article 27(3)(b) states that:

> Members may also exclude from patentability: plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any combination thereof.[141]

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[138] GIANCARLO MOSCHINI & OLEG YEROKHIN, AGRICULTURAL BIOTECHNOLOGY AND INTELLECTUAL PROPERTY: SEEDS OF CHANGE 190–94 (CAB International, 2007).
[139] *Id.* at 191, 193–94.
[140] Agreement on Trade-Related Aspects of Intellectual Property Rights art. 1, Jan. 1, 1995, 1869 U.N.T.S. 300 [hereinafter TRIPs].
[141] *Id.* at art. 27(3)(b).

As can be seen, the Article expressly provides that non-biological and microbiological processes may not be excluded from patentability, thereby ensuring patent protection for genetic modifications to plants produced through biolistic or *agrobacterium*-mediated gene insertion.

To the extent that the agreement requires protection for plant varieties in some form, member states need not adopt *UPOV*; they may fashion their own *sui generis*[142] systems from scratch. The *sui generis* option does not expressly constrain member states to enact legislation that protects breeders' rights as those are contemplated in such instruments as *UPOV*.[143] The language in *TRIPs* framing the obligation to enact PVPs is extremely broad; even if it requires the protection of the rights of breeders, the structure of those rights and the exemptions to them can be quite different to those provided for in *UPOV*.[144] Because the provisions of *UPOV* favour commercial breeding over traditional practices, developing countries still crafting national legislative responses to their obligations under *TRIPs* may find that the *sui generis* option is worth a close look.[145]

The foregoing discussion has focused on the United States and the EU in order to illustrate the ways in which the IPRs for plant varieties, transgenics, and traditional methods intertwine, and to demonstrate how the tenor and force of the national instruments can be linked to regional food security concerns.

The current regimes in IPRs for crop research and development show a global tendency to support genetic modification over conventional breeding and traditional practices. There is nonetheless a clear desire, albeit unevenly expressed, to promote both conventional and traditional methods. As we noted, however, there is a tension between breeders' rights and farmers' rights with respect to plant varieties, and the legislative instruments examined here both express that tension and signal the local policy perspective on the value of those respective rights.

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[142] Janis & Kesan, *supra* note 79, at 739.
[143] *See* Philippe Cullet & Radhika Koluru, *Plant Variety Protection and Farmers' Rights: Towards a Broader Understanding*, 24 DELHI L. REV. 41, 47–49 (2003).
[144] *See id.* at 45.
[145] The implementation of plant variety protection may need to be adjusted even in those countries that have already enacted legislation in order to fulfill new obligations arising from other international instruments, such as the *Convention on Biodiversity* or the *International Treaty on Plant Genetic Resources for Food and Agriculture*, which promote the protection of traditional practices and the rights of farmers (in opposition to those of breeders). The current implementation of the general framework of the *UPOV* through the *PVPA* and the *ECPVR*, for example, may not be in harmony with the requirements arising from commitment to these other international instruments. *See id.* at 47–49, 54.

D. *Transgenic Patents, Traditional Methods, and Terminators*

There is tension between patent rights for transgenic crops and farmers' rights as well. In the United States and the EU, the companies holding patents on transgenic plant technologies vigorously enforce their rights when these come into conflict with farming practices.[146]

The courts adjudicating such matters have frequently made findings that favour the patent holders.[147] The narrative of providing incentives for innovation is usually invoked in support of these findings. There is one extremely powerful rationale, however, that will likely continue to encourage judicial support of transgenic patent holders for the foreseeable future, and one that goes directly to the heart of food security: the availability of genetic use restriction technology, colloquially known as "terminator" technology. In essence, the technology allows for the control of plant fertility or longevity (e.g., by creating plants that produce sterile seeds).[148] This technology has been developed by several companies,[149] with Monsanto holding several key patents.[150]

To date, no one has commercialized it. There is profound opposition to the idea in the developing world: both India and Brazil have passed national laws prohibiting the technology.[151] The UN *Convention*

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[146] As illustrated by the three largest agri-biotech companies: Monsanto, Dupont Pioneer, and Syngenta. *See* Bowman v. Monsanto Co., 133 S. Ct. 1761 (2013); J.E.M. AG Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc., 534 U.S. 124 (2001); Complaint and Demand for Jury Trial, Pioneer Hi Bred Int'l v. Does 1–5, No. 5:12-cv-06046-DGK (W.D. Mo. filed May 11, 2012); Donald Zuhn, *Monsanto and Syngenta Settle All Litigation Between the Companies*, PATENT DOCS (May 30, 2008), http://www.patentdocs.org/2008/05/monsanto-and-sy.html [https://perma.cc/PFG6-QDYG].

[147] *See* Bowman, 133 S. Ct. at 1762; J.E.M. AG Supply, Inc., 534 U.S. at 595. For further illustration, but in the Canadian context, see also Monsanto Canada Inc. v Schmeiser, [2004] 1 S.C.R. 902 (Can.).

[148] HUGH WARWICK, GENEWATCH.ORG, SYNGENTA—SWITCHING OFF FARMERS' RIGHTS? 7 (Oct. 2000), *available at* http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/syngenta.pdf [https://perma.cc/8QF6-LUA7].

[149] *See Context of '1994 and after: Biotech Companies Obtain Patents on Genetic Use Restriction Technologies (GURT)'*, HISTORY COMMONS, http://www.historycommons.org/context.jsp?item=gm-161#gm-161 [https://perma.cc/AF5M-DDDZ]. (Companies having developed this technology include Novartis, AstraZeneca, Monsanto, Pioneer Hi-Bred, Rhone Poulenc, and DuPont).

[150] *See* WARWICK, *supra* note 148, at 14–15; *see also Monsanto Company History*, MONSANTO, http://www.monsanto.com/whoweare/pages/monsanto-history.aspx [https://perma.cc/8QAE-N5FK] (several patents are held through the Delta and Pine Land Company it acquired in 2007).

[151] Haider Rizvi, *Biodiversity: Don't Sell 'Suicide Seeds', Activists Warn*, INTER PRESS

on Biological Diversity adopted a *de facto* moratorium on field-testing and commercial sale of terminator-enabled seeds in 2000, reaffirming it in 2006.[152]

If any technology is capable of introducing the future nightmare of Bacigalupi's novel, genetic use restriction is the most likely candidate we have. Biotechnology companies that could profit from its deployment seem to be content, for the moment, not to do so. But the incentive to introduce terminator technology, and lobby against the creation of further legislation banning its use, could quite easily grow out of unfavourable court decisions or legislation that undermines the strength of patent protection. *Bowman* is a case in point: when the case was still under review by the Supreme Court, concerns about the outcome included worries that Monsanto might lift its self-imposed pledge not to commercialize its terminator technology.[153] Such worries are well-placed: because the business model for agricultural biotechnology is built upon strong patent protection, weakening that protection would force companies to seek other ways of shielding their market.

Deploying such technology could have disastrous consequences for food security. For example, for those countries with no local high-yield seed-producing companies that could be controlled through state action, terminator technology on imported high-yield seed would unacceptably compromise food sovereignty. It is no response to say that if a company introduced such technology into its seed products, farmers could simply decide not to buy that product. Competitive market pressure will naturally increase the uptake of seed for high-yield crops in any given region. Introducing a ban on the importation or use of genetically modified seed, even if it were feasible in the short term, is unlikely to furnish a long term solution. If the only way to assure a quantity of output sufficient to match increasing national food supply needs were to buy a transgenic seed with terminator technology, such a ban would be unsustainable.

Terminator technology would also undermine the effectiveness of emergency measures such as compulsory low-cost licensing. The

SERV. NEWS AGENCY, (2006), http://www.ipsnews.net/2006/03/biodiversity-don't-sell-suicide-seeds-activists-warn/ [https://perma.cc/MJG6-RQ87].

[152] *See* FIFTH ORDINARY MEETING OF THE CONFERENCE OF THE PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY, Decision V/5, III at 23 (May 2000); *see also* Moratorium, BAN TERMINATOR, http://www.banterminator.org/Glossary/Moratorium [https://perma.cc/US4L-KLBM].

[153] Heidi Ledford, *Seed-patent Case in Supreme Court*, 494 NATURE 289 (Feb. 2003), *available at* http://www.nature.com/news/seed-patent-case-in-supreme-court-1.12445 [https://perma.cc/8B9C-3ET7].

introduction of compulsory licensing of a particular foreign producer's high-yield seed would be pointless if the producer's seed stock already in the country had been loaded with genetic use restriction technology, and the foreign seed producer were unwilling to import more. At least with the current array of fertile transgenic seed stocks, governments faced with food security crises could legislate emergency suspension of IPRs immediately and sort out equitable remuneration for the producers later.

I conclude that in any current contest between patents on transgenic plants and farmers' rights to save or exchange seeds, farmers will lose. In the absence of a globally enforceable ban on terminator technology, courts and legislators are, I think, quite rightly willing to abandon the protection of traditional practices where those compete with transgenic seeds in particular.

This is not intended to suggest that the ever-enlarging market in transgenic seed stock must spell the end of traditional practices. These practices are supportable with the right adjustments to existing IPR regimes. It is to a consideration of such adjustments that we will now turn.

V. IMPROVING THE LANDSCAPE

As mentioned at the outset, the national legislative choices made by countries who are party to the various international agreements discussed above will have significant impact on the evolution of food security, both from a national and a global perspective. The ideal would be a regime that encourages, or at least does not interfere with, the formal and informal research programs that between them contribute to increased crop yield and biodiversity. As we have seen, the distribution of strong IP protections (and specific exemptions from those protections) encourages the distribution of research investment into strategies with different risk profiles, but the support for biodiversity provided by such protections as they are currently implemented is uncertain.

Some have argued that implementing strong, uniform intellectual property protections may not be wise for all countries, developing countries in particular.[154] Insofar as traditional farming practices contribute to biodiversity, and developing countries rely on the robustness of such practices (as opposed to industrial agriculture), the relatively weak support for farmers under *UPOV* and derivative statutes, and the absence

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[154] IP JUSTICE POLICY PAPER FOR THE WIPO DEVELOPMENT AGENDA, IP JUSTICE (June 2005), *available at* http://ipjustice.org/WIPO/WIPO_DA_IP_Justice_Policy_Paper.pdf [https://perma.cc/BPW9-LQ3Z].

of such support under patent legislation, arguably harms the interests of developing countries.

In this section, I will argue that some improvement on the current regime may be possible. What will be proposed is not a total cure; as we shall discuss, below, because there is no practical scope for adjustment of the patent regime, there is therefore no scope for diminishing the competition between transgenic plant research and traditional practices. However, with respect to plant varieties, the existing tissue of agreements and legislative instruments may permit stronger protections for shorter terms.

These shorter terms might spur an accelerated cycle of innovation for capital-intensive commercial breeding. The need to satisfy shareholder demand for steady or increasing revenue streams requires a pipeline of new products enjoying the protections of IPRs. Because of the underlying mechanics of plant breeding, an accelerated cycle of innovation may act as a proxy incentive for biodiversity. At the same time, an argument can be made that the faster flow of new varieties into the public domain could support traditional practices more effectively than weaker IPR protections coupled with longer terms.

We will canvass alternatives as we go; but if what is ultimately needed in order to balance innovation and biodiversity is a mixture of strong protections, suitably distributed, and shorter terms, the question then becomes: is it possible to work within the existing framework to achieve this goal or a suitable proxy for it? In the final discussion on utility models, I argue that the answer is yes.

A. Shortening the Term of Protection

Prior to the enticements offered by WTO membership, states designed domestic intellectual property law to suit their economic circumstances, and ensured that the international agreements they were negotiating left them the flexibility to do so.[155] With the advent of *TRIPs*, that flexibility has been diminished.

When *TRIPs* was first signed, twenty-year terms had already become a *de facto* standard for patent protection in many jurisdictions. The migration of that standard into the international agreement[156] was

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[155] PETER DRAHOS WITH JOHN BRAITHWAITE, INFORMATION FEUDALISM: WHO OWNS THE KNOWLEDGE ECONOMY? 38 (2002).
[156] *See* TRIPs, *supra* note 140, at art. 33.

therefore predictable and might even seem rational, given that the goal of *TRIPs* is the harmonization of IPR regimes worldwide.

However, from a broader perspective, the uniformity of the twenty-year patent term is difficult to justify—even if we were to assume that the period was not chosen arbitrarily.[157] One of the potential effects of long patent terms is a decrease in the pace of innovation,[158] especially in capital-intensive research programs. Contentment with steady revenue streams arising from existing patents may discourage shareholders in corporations—who may have invested in order to bring those revenue streams online—from maintaining corporate directors who themselves support further extensive (and therefore expensive) R&D investment.[159]

One rational foundation for the choice of a particular patent term length is the desire to strike a balance between the amount of investment required and the time needed for recovery. Changes in market size, however, can result in serious distortions. A recent study that considered the influence of market scale on the incentive to innovate, factoring in R&D expenditures, population growth, and GDP per capita, concluded that as market size increases, IP protection should be reduced—in the case of patents, the optimal term being about ten years.[160]

This argument could be fairly applied to the current international order in IPRs. It is true that *TRIPs* is not an international patent system *per se*, but rather a harmonization instrument.[161] The purpose of the instrument, however, is to furnish at least some of the benefits that an international system would provide; in particular, larger markets for inventions.[162] This is why ratification of *TRIPs* is compulsory for membership in the WTO: it is regarded as an instrument for the promotion of

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[157] *See* Reuven Brenner, *Must All Patents Last for 20 Years?*, WALL ST. J., Apr. 23, 2013, *available at* http://www.wsj.com/articles/SB100014241278873245047045784131542122 18668 [https://perma.cc/9M4D-NGKV] (It is not clear to what extent we should assume that the choice was reasoned. The first U.S. patents were 14 years in length. Congress later extended them to 21 years; the term was later shortened to 17 years, which lasted until 1999.).

[158] *See, e.g.*, Frank H. Alpert, *An Analysis of Patent Length: Encouraging Innovation by Shortening Patent Protection*, 11 J. MACROMARKETING 40 (1991).

[159] *See, e.g.*, J. Bessen & R. Hunt, *An Empirical Look at Software Patents* (Federal Reserve Bank of Philadelphia, Working Paper No 03-17, 2004).

[160] Michele Boldren & David K. Levine, *Market Size and Intellectual Property Protection*, 50 INT'L ECON. REV. 855, 876 (2009).

[161] *See* Cullet & Koluru, *supra* note 143, at 45 (describing minimum standards applied by TRIPs to all member states).

[162] *Id.* at 41.

trade,[163] providing for enforceable IPRs in new markets where rights holders wish to sell their inventions, rather than as an instrument to encourage invention. When coupled with devices such as the *Patent Cooperation Treaty*,[164] the national implementation of *TRIPs* requirements creates an efficient route to rapidly enlarging the market for a given innovation.

As the market for an innovation enlarges, however, the rewards enlarge as well, making recovery of investment more rapid. Uniformly extending patent terms appropriate to national contexts into the global context, where inventors can enlarge their markets by filing foreign patents everywhere that *TRIPs*-compliant provisions are in force, is therefore difficult to justify.

Shorter patent terms, however, will not make sense in all cases. Taken in the aggregate, larger markets should lead to shorter terms overall; but disaggregation of the data shows that different research programs have different optimal terms of protection. Pharmaceutical innovations, for example, have high returns and high costs;[165] this may be contrasted with the software industry, where R&D costs can be vanishingly small and the returns enormous.[166] It is entirely possible that for certain innovating sectors of industry, *longer* patent terms would be optimal, and that for others the twenty-year current standard is close enough to the relevant optimum.

For example, it may be beneficial to maintain the current patent term for transgenic plant research. Anxieties about the safety of GM foods in general—and, perhaps, hostility towards transgenic foods and the companies that produce them in particular—have contributed to the creation of a substantial regulatory burden for this sector in some jurisdictions.[167]

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[163] *See* JOHN BRAITHWAITE & PETER DRAHOS, GLOBAL BUSINESS REGULATION, ch. 7 (2000) (In the United States, trade policy has been linked to maximization of intellectual property privileges for several decades.).
[164] *See* Patent Cooperation Treaty, 1160 U.N.T.S. 231 (1970) (The treaty provides a unified application procedure for filing patents in each of its contracting states.) [hereinafter PCT].
[165] Boldren & Levine, *supra* note 160, at 862.
[166] *See* Joe Mullin, *The Web's Longest Nightmare Ends: Eolas' patents are Dead on Appeal*, ARS TECHNICA (2013), http://arstechnica.com/information-technology/2007/08/microsoft-and-eolas-settle-ending-patent-battle-over-plug-ins-activex/ [https://perma.cc/Z4VD-ZLSW] (One admittedly egregious example: the Eolas patent on the "interactive web," for which the patent holder originally won a $540 million U.S.D. jury verdict.).
[167] *See* Diahanna Lynch & David Vogel, *The Regulation of GMOs in Europe and the United States: A Case-Study of Contemporary European Regulatory Politics*, COUNCIL ON FOREIGN RELATIONS (2001), http://www.cfr.org/agricultural-policy/regulation-gmos-europe-united

It has been estimated that, in Europe, regulatory clearance absorbs approximately half of the R&D investment in any given transgenic crop plant.[168] Moreover, the biosafety assessment portion of regulatory compliance accounts for only a fraction of the total, and as was pointed out earlier, current biosafety regimes leave a lot to be desired in terms of the depth of investigation that transgenics arguably warrant.[169] The regulatory burden will likely continue to increase, especially if dependence on the high yields of transgenic crops becomes more widespread and more closely tied to food security as opposed to profit.

As the transgenic research program matures and its long-term outcomes become better understood, the regulatory environment will settle and the sector's economic fortunes will become more predictable. At that point, it may be worth considering whether the length of the current patent term in this sector is defensible. At present, however, high existing R&D costs and uncertainty about the future character of the regulatory burden and its associated costs present a strong argument against tinkering with either the length of the patent term or the strength of patent protections for transgenics.

In concluding, it bears mentioning that the probability of turning the international ship towards shorter patent terms is vanishingly small. There are, among other factors, far too many vested interests that benefit from the current terms. Hence, while it is interesting to contemplate the social benefits of shorter patent terms from a policy perspective, the likelihood is that the terms embedded in *TRIPs* will become more, and not less, entrenched.

B. Compulsory Licensing

If circumstances require it, international negotiations may be held to modify the extent or rigidity of *TRIPs* obligations. This has happened before: the WTO Ministerial Conference of November 2001, held in Doha, adopted an interpretative statement entitled the *Declaration on the TRIPs Agreement and Public Health*,[170] reaffirming "the flexibility of *TRIPs*

-states-case-study-contemporary-european-regulatory-politics/p8688 [https://perma.cc/GTE9-S2D9].

[168] *See* Willy De Greef, *GM Crops: The Crushing Cost of Regulation*, AGBIOWORLD (2011) http://www.agbioworld.org/biotech-info/articles/biotech-art/crushingcost.html [https://perma.cc/VWT3-7PSP] (This can amount to millions of dollars in each case.).

[169] *See* Kuiper et al., *supra* note 45.

[170] WTO Ministerial Conference, *Declaration on the TRIPs Agreement and Public Health*, WT/MIN(01)/DEC/2 (*adopted* Nov. 14, 2001), *available at* https://docs.wto.org/dol2fe

member states in circumventing patent rights for better access to essential medicines."[171] This interpretative statement was later strengthened into an amendment allowing WTO members to enact legislation for compulsory licenses for generic versions of patented medicines, but its future success is uncertain; as of this time, only forty-five countries have accepted it.[172]

In the event of a food security crisis arising from crop failures, it is possible that a future round of WTO talks could adopt a similar declaration directed at compulsory licensing for patented transgenic plants or plant varieties for member states who consider their food security to be at risk from climate change or changing ecosystem disease profiles, further leveraging article 8 of *TRIPs*:

> Members may, in formulating or amending their laws and regulations, adopt measures necessary to protect public health and nutrition, and to promote the public interest in sectors of vital importance to their socio-economic and technological development, provided that such measures are consistent with the provisions of this Agreement.[173]

Compulsory licensing may have deleterious effects on biodiversity, however. The long term effects of compulsory licensing as a prophylactic measure against a perceived food security threat could increase a tendency to monoculture, and thereby risk destabilizing crop yields catastrophically in the future. The possibility of such outcomes may be increased where a country adopting such compulsory licensing legislation on terms favourable to farmers was adjacent to a country without such legislation. The potential market differentials between such neighbors could encourage farmers to cultivate the cheaply licensed high-yield crop varieties to a greater extent than the government intended: the surplus would fetch a profit on foreign regional markets. Hence such compulsory licensing

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/Pages/FE_Search/FE_S_S009-DP.aspx?language=E&CatalogueIdList=35625,33346,31335,18756,37246,35766,37254,17243,35772,37509&CurrentCatalogueIdIndex=5&FullTextSearch= [https://perma.cc/C8M2-CSU4] [hereinafter *Doha Declaration*].

[171] *Id.*

[172] *Members accepting amendment of the TRIPs Agreement*, WORLD TRADE ORG., http://www.wto.org/english/tratop_e/trips_e/amendment_e.htm [https://perma.cc/8EEF-ZQRJ] (last visited Mar. 27, 2016) (The quorum for formal incorporation of the amendment is two-thirds of the 153 members of the WTO, and the deadline for adoption (extended twice) is presently set to expire on December 31 2017.).

[173] TRIPs, *supra* note 140, at art. 8; *see also* TRIPs, *supra* note 140, at art. 27(2)–(3).

regimes, even if they were available, would only be a partial solution best deployed in urgent circumstances.

C. *Weakening Protections*

An alternative strategy would be to weaken the potency of *TRIPs*-compliant statutory schemes with respect to plant varieties in particular. Because *TRIPs* permits the possibility of enacting *sui generis* protections for plant varieties, one possibility would be to enact a national version of *UPOV* that takes full advantage of the optional exemptions provided for farmers: allowing them, as the *PVPA* does, to save and reuse seeds from year to year, without having to remunerate commercial breeders. This would permit farmers to perform their own local breeding experiments with different breeds they purchase under license, even though the fruits of those experiments would be restricted to their private use. This could provide some level of localized support for biodiversity by assisting the creation of a reserve (albeit atomized) of different essentially derived varieties. That could then be leveraged in the face of any regional food security issues arising from changing conditions in local ecosystems, through subsequent compulsory licensing of those varieties with royalty rates favourable to farmers.[174]

As noted above, however, the informal research program furnished by traditional practice is relatively inefficient, and its efficiency is further curtailed by *UPOV*'s mandatory restriction on *exchange* of seeds covered by PVP and the protection of essentially derived varieties. To pin all hope of promoting biodiversity on this form of research would be unwise. It is highly unlikely that the rate at which new varieties would be generated by this method will substantially contribute to the stability of food supply needed to cope with rising global demand curves, to say nothing of the need for increased crop productivity.

The weakening of existing protections is a strategy with potential long-term payoff, but our present situation needs short-to-medium-term solutions. In addition, this strategy would have at least some negative impact on investment in commercial breeding, by diminishing repeat sales of plant varieties protected under such relaxed *UPOV*-style legislation. Any such reduction in investment on commercial breeding will undermine

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[174] In order to be effective, this suggestion would need to be accompanied by an exclusionary legislative regime such as that adopted by the EU, whereby plant varieties are excluded from the statutory protections afforded by patents.

the increased-yield plant varieties that such breeding aims at, sacrificing productivity improvements for biodiversity.

D. *Alternative Protections for Plant Varieties: The Utility Model*

TRIPs compliance requires maintenance of lengthy patent terms, and exploiting the flexibilities of *UPOV* and *TRIPs* alone in service of supporting farmers' rights is unlikely to yield the kinds of benefits we need in the near term. However, when combined with utility models as outlined below, a weakened form of the existing framework has the potential to alter incentives for commercial breeding research programmes in ways beneficial to biodiversity.

1. Utility Models

Utility models are similar to patents, but the conditions under which they are granted are considerably less strict.[175] The offices examining utility model requests do not conduct thorough examinations as they would for standard patents, often granting the utility model if the application complies with formalities.[176] Most importantly, utility model protection typically extends to a much shorter term than patents, ranging between six and fifteen years depending on the jurisdiction,[177] and is generally considered (where available) suitable for "incremental inventions".[178]

Utility models have not been universally adopted, although they are recognized under the *Paris Convention for the Protection of Industrial Property*,[179] and therefore under *TRIPs* by extension.[180] There is, however, no explicit mention of utility models within the body of *TRIPs*. In consequence, the incorporation of the *Paris Convention* provisions leaves WTO

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[175] *Protecting Innovations by Utility Models*, WORLD INTELLECTUAL PROP. ORG., http://www.wipo.int/sme/en/ip_business/utility_models/utility_models.htm [https://perma.cc/2PMR-36AT].
[176] *Id.*
[177] *Id.*
[178] *Id.*
[179] Paris Convention for the Protection of Industrial Property, art. 1(2), July 14, 1967, 21 U.S.T. 1583, 828 U.N.T.S. 305 [hereinafter Paris Convention] ("The protection of industrial property has as its object patents, *utility models*, industrial designs, trade marks . . ." [emphasis added]).
[180] *See* TRIPs, *supra* note 140, at art. 2(1).

members free to define the scope and duration of protection under any utility model laws they choose to enact.[181]

As it stands, most countries that have utility model legislation expressly exclude plant and animal varieties;[182] but there is no fundamental reason that such exclusions, where they do exist, could not be modified. In this respect, countries wishing to enact utility model legislation that provides protection for plant varieties could exploit two known features of utility models: that they are intended for protection of "incremental" inventions, and that there is no international consensus on what this means.[183]

The efforts of commercial breeders, it could be argued, fall within the concept of incremental invention. The creation of new plant varieties that exhibit a particular desirable trait, or a small collection of such traits, could be construed as an incremental modification of a basic natural variety, or an incremental advance on a previously bred variety. Because of the lack of consensus on what "incremental" amounts to generally, individual jurisdictions would be free to decide what might be included as protectable subject matter with respect to plant varieties within the context of utility models.

2. Combining Utility Models with Weakened UPOV Protections

Crucially, because *UPOV* does not prohibit other forms of protection for plant varieties—as the jurisprudence in the United States regarding the patentability of plant varieties has shown—implementing a utility model regime in parallel with *UPOV*-style legislation is clearly possible. This introduces the potential for materially improving both support for commercial breeding research and net biodiversity simultaneously.

For example, a strong utility model regime providing protection for plant varieties but with no exemptions for farmers could be coupled with the weakened *UPOV* regime described just above in section V.C. The two regimes could include provisions excluding the exploitation of both regimes in respect of a given innovation. Commercial breeders electing to register a new plant variety under the utility model regime would thereby forego the possibility of ever registering that variety under the weakened *UPOV* regime.

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[181] UMA SUTHERSANEN ET AL., INNOVATION WITHOUT PATENTS: HARNESSING THE CREATIVE SPIRIT IN A DIVERSE WORLD 21 (2007).
[182] *See* The Consolidate Utility Models Act No. 1431 of 21 December 2005, art. 2(4).
[183] *See* Suthersanen et al., *supra* note 181, at 18–20.

It bears mentioning, at this point, that this proposal remains compatible with the text of the *Trans-Pacific Partnership*.[184] This compatibility does not rely on the *TPP*'s recognition of the *Doha Declaration* or the general right of parties to take measures to protect public health,[185] and exists in spite of the fact that the *TPP* did not import the *TRIPs* provision for *sui generis* systems.[186] The compatibility arises instead from the commitment to ratify the 1991 version of *UPOV* by the local date of entry into force of the *TPP*.[187] As a result, any party to the *TPP* could fulfill its requirements by adopting a maximally weakened version of *UPOV*'s protections for plant varieties as discussed above, and instituting in parallel the utility model regime proposed here.

Suitably structured, such a regime would provide an incentive for commercial breeders to prefer utility model protection for their innovations. The strong protection could be extended to include protection for essentially derived varieties, thereby providing the same safeguards of the most recent version of *UPOV*, with the understanding that when the protection for the initial variety expires, all essentially derived varieties would thereby also be released into the public domain.

Assuming the foregoing, and assuming a fairly short term for utility model protections for plant varieties (say, six years), the net effect would be strong protection for a short term, permitting the products of commercial breeding to enter the public domain rapidly. In consequence, commercial breeders would have strong incentives to invest in the rapid production of new varieties, and in particular varieties that escape the designation "essentially derived," so that these could be independently protected and would continue to create revenue streams even as earlier utility model protections expired. I venture to suggest that such an accelerated cycle of plant breeding would require experimentation with a wide variety of input plants, thereby increasing biodiversity in the output.

Moreover, although the proposed utility model regime would prevent seed saving and exchange for protected varieties, the rapid diffusion of desirable plant varieties into the public domain might well help sustain those traditional practices better than our current legislative framework.

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[184] *See* TRANS-PACIFIC PARTNERSHIP, INTELLECTUAL PROPERTY CHAPTER, art. 18 (Feb. 2, 2016) [hereinafter TPP], *available at* https://medium.com/the-trans-pacific-partnership/intellectual-property-3479efdc7adf#.vsmr7gvy6 [https://perma.cc/F7C3-P3GF].

[185] *See* TPP, art. 18.6.

[186] *See, e.g.*, TPP, art. 18.37(4). The *TPP* provides only an exceptional option for New Zealand. *See* TPP, Annex 18-A(1)(b).

[187] *See* TPP, art. 18.7(2)(d). Except for New Zealand, see TPP, Annex 18-A(1)(b).

If twenty-year protections preventing seed exchange are coupled with a widespread desire to use protected seed products for such reasons as yield or hardiness, the net effect could be a moratorium on seed saving and exchange for the length of a human generation. By the time the protection has expired, moreover, it is very likely that the farmers will have moved on to better seeds still under protection. A shorter term, such as six years, might be short enough to maintain the traditional practices within each generation and hence between generations as well.

It might be argued that providing strong, exceptionless protections for commercial breeders would not offset the discouraging effects of the short term of protection, and that the net result would therefore be a decline in commercial breeding investment in general. Three arguments may be made against this, however.

To begin with, if a commercial breeding enterprise of small-to-medium size found that their revenue streams were too limited to support the amount of investment in R&D required to provide rapid output of new varieties, they could form collaborations with other breeders in order to pool resources. Failing the effectiveness of such cooperation, some market consolidation might take place, as larger breeders might be able to exploit economies of scale in their R&D investments.

Secondly, utility model protections may exploit the international application framework provided by the PCT. Article 2(i) of the PCT states that:

> For the purposes of this Treaty and the Regulations and unless expressly stated otherwise:
>
> (i) "application" means an application for the protection of an invention; references to an "application" shall be construed as references to applications for patents for inventions, inventors' certificates, *utility certificates, utility models*, patents or certificates of addition, inventors' certificates of addition, and utility certificates of addition.[188]

When we couple the availability of this mechanism with the relatively low burden imposed on application requirements for utility models in general, the possibility for commercial breeders to secure an enlarged market for their varieties at low cost may sufficiently offset the discouraging

[188] PCT, *supra* note 164, at art. 2(i) [emphasis added].

effects of the short term of protection that their products would enjoy in each jurisdiction. For this advantage to exist, however, would require that several jurisdictions with markets of significant size adopt similar utility model legislation, allowing for protection of plant varieties.

Finally, not all investors have the appetite for the high R&D costs, fluctuating regulatory burdens, and substantial controversy that afflict investments in transgenics, despite the potential for higher rewards. The performance of commercial breeding companies is, for these reasons, already somewhat more predictable and lower risk than their commercial transgenic research counterparts. Strengthening protection for their products through utility models would add to that predictability and attract investment from those who seek steady return.

Despite its several attractions, this proposal is not without its drawbacks. Because utility models have lower thresholds on eligibility for protection than patents, the use of utility models might facilitate biopiracy. The Enola bean offers a case in point. In the mid-1990s, John Proctor bought some mixed *Phaseolus vulgaris* beans in Mexico and returned to the United States.[189] He selected the yellow beans and grew them into plants, harvested the result, and replanted for a few seasons.[190] He then applied for, and received, a U.S. patent on *Phaseolus vulgaris* beans having a particular shade of yellow in 1999.[191]

Having secured the patent, Proctor enforced it by demanding a 6-cent-per-pound royalty on all importation of yellow *Phaseolus vulgaris* beans into the United States.[192] While the challenges to his patent wound their way through the courts, his royalty remained enforceable and led to a significant reduction of bean imports from Mexico.[193] The patent was ultimately defeated at the hands of the Federal Circuit Court of Appeals, which founded its decision on a finding that the patent claim was for an obvious variation of a well-known yellow bean;[194] but a substantial amount of damage to Mexican bean farmers had already been done.

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[189] *See* Gillian N. Rattray, *The Enola Bean Patent Controversy: Biopiracy, Novelty and Fish-and-Chips,* 1 DUKE L. & TECH REV. 1, 1–2 (2002).
[190] *Id.*
[191] *Id.*; *see also* Dennis Crouch, *Mexican Yellow Bean Patent Finally Cooked*, PATENTLYO (July 10, 2009), http://patentlyo.com/patent/2009/07/mexican-yellow-bean-patent-finally-cooked.html [https://perma.cc/FG9X-LTAC].
[192] Crouch, *supra* note 191.
[193] Rattray, *supra* note 189.
[194] Phil Jones, *Federal Circuits Cooks Bean Patent While Another Patent Dispute Simmers*, ISB NEWS REPORT (Feb. 2010), http://www.isb.vt.edu/news/2010/Feb/FederalCircuitsCooksBeanPatentarticle.pdf [https://perma.cc/P88P-YSLK].

Utility models as currently implemented have variable thresholds for novelty, and weakness in this area could well translate into more widespread exploitation of the protective regime on dubious grounds. Even if the standards were made more stringent, the general rule that sees utility models initially approved simply by fulfilling the formal steps might lead to the kinds of market-distorting effects that Proctor's illegitimate patent created for a decade.

Adoption of utility models as a proxy for shorter patent terms, therefore, may well require the application of a more stringent approval process, and thresholds in line with those of standard patents. Nevertheless, in my view, suitable exploitation of utility models would offer a better distribution of support for the three research programs discussed here than could be achieved by weakened *UPOV*-style protections on their own or, for that matter, the status quo.

CONCLUSION

We began with a brief excursion into futures imagined and real. Neither, frankly speaking, is particularly encouraging. That there will be compromise and change is virtually certain; how it will all shake out is unknown. In the meantime, we must hedge our bets. What has been discussed above offers a small sliver of improvement, a possible medium term solution. It is specific to our current circumstances, taking into account existing legal regimes, socio-political trends, the mechanics of the research programs we have chosen to support (including traditional practices) and the public perspective on those programs.

In our interconnected age, life has become an uncontrolled experiment with a single test subject: what we create or change anywhere may, for better or for worse, have influence on the whole. Because the stakes are therefore higher, it is prudent for us to spread our search for solutions into as many research programmes as is practical. We prefer markets to organize a good deal of this research activity, and as such we must be content to work with IPRs and to coordinate our efforts in this regard. Of course in the case of widespread catastrophe, we can always pull on emergency levers: temporary suspension of IPRs or compulsory licensing. Yet such levers must be used sparingly; overuse will affect revenues, which will discourage investment and ultimately research.

Despite the attempts made to harmonize IPRs through such instruments as *UPOV* and *TRIPs*, the terms of agreement are unsubtle and the implementation chaotic: the standards tend towards one-size-fits-all, and the several instruments and agendas are in various stages of implementation, with more on the horizon in the form of the *TPP*. Yet wholesale reform, which might be the optimal solution from a formal perspective, is simply not feasible. The creation and national adoption of international instruments, especially those that call for actual reform of existing national law as opposed to mere accretion, operate on timescales that exceed what we can afford with respect to food security.

Fortunately for us, western legal traditions have longstanding familiarity with the challenge of adapting existing laws to changing circumstances, avoiding grand transformations of legal form yet achieving the practical outcomes desired. Although I think this adaptive capacity not limited to the common law, Blackstone expressed it well:

> Our system of remedial law resembles an old Gothic castle, erected in the days of chivalry, but fitted up for a modern inhabitant. The moated ramparts, the embattled towers, and the trophied halls, are magnificent and venerable, but useless, and therefore neglected. The interior apartments, now accommodated to daily use, are cheerful and commodious, though their approaches may be winding and difficult.[195]

The proposal here, to adopt utility models in order to address the shortcomings of the current regime governed by *UPOV* and *TRIPs*, circumvents the need for grand reform. It could nevertheless effect significant change, providing better support for biodiversity through accelerated research in commercial breeding, and possibly for traditional practices as well. There is no question that from a formal perspective, this way of proceeding makes our arrangements seem messy; but if we want to keep the *whole* castle, we must be willing to tolerate its idiosyncrasies.

As Blackstone noted, however, venerable though our previous arrangements may be, they are not always useful. Through changes in sentiment, interest, or circumstance, we may later decide to demolish certain halls and towers, rather than keeping them largely unlit and unused. When we do, we may also take the opportunity to build new apartments, and thereby new traditions, together.

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[195] WILLIAM BLACKSTONE, COMMENTARIES ON THE LAWS OF ENGLAND 267–68 (1767).