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A Game-Theoretic Approach to Modelling Crop Royalties

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Abstract

Plant variety rights assist crop breeders to appropriate returns from new varieties and incentivise varietal improvement. Royalties are one form of plant variety rights and this dissertation asks which combination of the available royalty instruments is best from the perspective of consumers, farmers, crop breeders, and the overall economy.

We use a game-theoretic approach to model strategic interactions between breeders and farmers. The model allows farmer privilege, whereby farmers save seed one year to plant in the future, and we show a point-of-sale royalty with either or both of the remaining royalties is optimal, whether or not we allow the possibility of farmers under-paying royalties through under-declaring output or saved seed.

We also develop a Principal–Agent model, in which risk-neutral breeders share the risk with risk-averse farmers. In this model, the optimum royalty depends on various parameters, including the costs of compliance and enforcement.

KEYWORDS: game-theory; economic model; end-point royalty; point-of-sale royalty; saved seed; farmer privilege; principal–agent model.

Declaration

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Acronyms and Abbreviations

ACCC	Australian Competition and Consumer Commission
ACIP	Advisory Council on Intellectual Property
AGT	Australian Grain Technologies
AVC	Average variable costs
AWB	Australian Wheat Board
Bt	Bacillus thuringiensis
CARA	Constant absolute risk aversion
COGGO	Council of Grain Grower Organisations Ltd
CRS	Constant returns to scale (production function)
CV	Coefficient of variation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EPR	End-point royalty
EU	European Union; Expected utility
FAO	Food and Agriculture Organisation of the United Nations
GM	Genetically modified
GRDC	Grains Research Development Corporation
IC	Incentive compatibility constraint of the farmer
ImpC	Implementability constraint of the farmer
IP	Intellectual property
IPR	Intellectual property rights
IR	Individual rationality constraint of the farmer
MV	Mean–variance (model)
NVT	National variety trials
NZPFR	New Zealand Institute for Plant and Food Research
PBR	Plant Breeder's Rights
POS	Point-of-sale royalty
PVP	Plant variety protection
PVPA	Plant Variety Protection Act of 1970, US
PVR	Plant variety rights
R&D	Research and development
RDC	Research development corporation
RR	Royalty revenue
SARDI	The South Australian Research and Development Institute

SSP	Saved-seed royalty
SW	Social welfare, the sum of farmer and breeder profits
TRIPS	(agreement on) Trade-Related Aspects of Intellectual Property Rights
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
US, USA	United States of America
UPOV	International Union for the Protection of New Varieties of Plants

Symbols

Game-theoretic models

a	enforcement costs parameter, $a > 0$, \$
b	proportion of farm sown to bought, new, seed, $b \in [0, 1]$; may be indexed by time period t
C	farmer's costs, \$
d	output-declaration rate, $d \in [0, 1]$
f	fine factor on cheating , $f > 1$
F	production function of wheat
g	marginal breeding cost, $g > 0$, \$ per kilogram of seed produced
K	fixed cost of wheat breeding, \$
m	saved-seed declaration rate, $m \in [0, 1]$
P_b	point-of-sale royalty, $P_b \geq 0$, \$ per kilogram of bought seed
P_s	saved-seed royalty, $P_s \geq 0$, \$ per kilogram of seed saved
$\bar{q}$	quality of new, bought, seed, tonnes of output per unit area
q	quality of the seed mix, tonnes of output per unit area; may be indexed by time period t
Q	production, output of wheat, tonnes; may be indexed by time period t
r	end-point royalty rate, $r \in [0, 1]$, \$ per tonne of output
X	enforcement cost function, \$

Greek symbols

β	discount factor, $\beta \in [0, 1]$
ϕ	probability of the farmer being investigated, $\phi \in [0, 1]$
ψ	seeding rate, tonnes of seed per unit area sown, $\psi > 0$
π_f	profit of the farmer, \$; may be indexed by time period t
π_B	profit of the breeder, \$; may be indexed by time period t
Π	discounted sum of future expected profits of farmer, \$
θ	quality of saved seed relative to new seed, $\theta \in (0, 1)$

Principal–Agent models

a	marginal enforcement costs, \$ per kilogram of seed
A	fixed enforcement costs, \$
b	quantity of seed bought by the farmer, kilograms
c, $\tilde{c}$	cost parameter of wheat growing, \$ per kilogram^2 of seed input
e	effort of the farmer in labour units
F	production function of wheat
g	marginal cost of wheat breeding, \$ per kilogram of seed
h	marginal product of farmer effort, tonnes of output per unit of labour effort
K	fixed cost of wheat breeding, \$
l	license fee, fixed up–front payment, \$
L	risk premium
N	numeraire unit of money $=$ output price
p	point-of-sale royalty, $p \geq 0$, \$ per kilogram of bought seed
q	production, output of wheat, tonnes
r	end-point royalty rate, $r \in [0, 1]$, \$ per tonne of output
v	marginal product of seed, \$ of output per kilogram of seed
Z	certainty equivalent of the farmer's wealth; Z is such that $EU(Y) = U(Z)$, if Y denotes the farmer's wealth, \$

Greek symbols

ϵ	uncertainty of production, a random variable with mean 0 and variance σ^2, \$ of output per kilogram of input
γ	coefficient of risk aversion of the farmer
π_f	profit of the farmer, \$
π_B	profit of the breeder, \$
σ^2	variance of ϵ, (\$ per kilogram of seed)^2