What is Really Driving Innovation in our Plant-based Sectors?

An economic analysis for the Review of the Plant Variety Rights Act 1987

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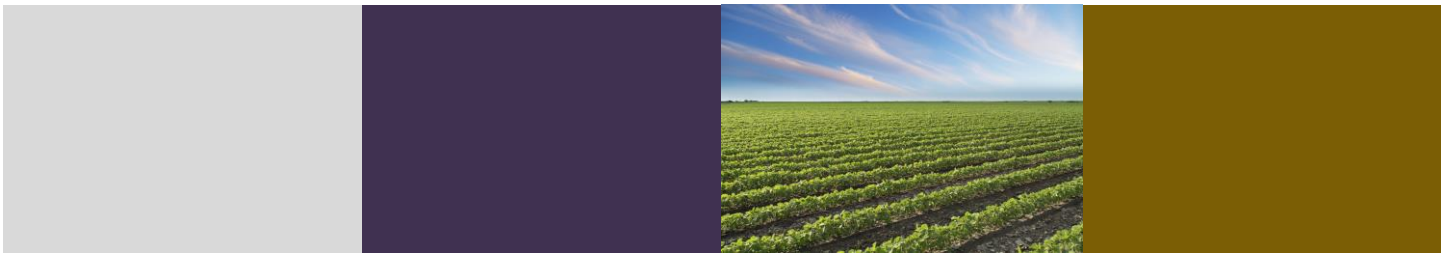

Contents

Appendices

Tables

Figures

Glossary

Abbreviation	Stands for
CPTPP	The Comprehensive and Progressive Agreement for Trans-Pacific Partnership, which is a free trade agreement involving New Zealand and 10 other countries in the Asia Pacific region.
PVR	Plant Variety Rights
PBR	Plant Breeders' Rights
MBIE	Ministry of Business, Innovation and Employment
IP	Intellectual Property
PVR Act	Plant Variety Rights Act 1987
UPOV 91	International Convention For The Protection Of New Varieties Of Plants of December 2, 1961, as Revised at Geneva on November 10, 1972, on October 23, 1978, and on March 19, 1991
UPOV 78	International Convention For The Protection Of New Varieties Of Plants of December 2, 1961, as revised at Geneva on November 10, 1972, and on October 23, 1978

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Executive summary

MBIE commissioned the authors to prepare this report as part of its review of the Plant Variety Rights Act. This report is intended to provide independent, objective information for policy-setting.

The Plant Variety Act provides for intellectual property protection for new varieties of plants. At a simple level, the Plant Variety Rights Act attempts to provide a balance between providing an opportunity for a plant breeder to obtain a reward for their effort in developing a new plant variety, and the benefits to growers and society from having access to new and improved plant varieties.

This report develops three aspects: (i) a framework for considering plant-based innovation in context; (ii) information about what is happening behind the scenes in New Zealand's plant-based innovation systems; and (iii) an evaluation which asks, is New Zealand missing out on better plant varieties, and are our legislative settings to blame? We were asked specifically to consider the settings around compulsory licensing, rights over harvested material and the ability for farmers to 'save seeds'.

The framework

There are three, mutually-reinforcing drivers of plant-based innovation in New Zealand. Each of these drivers push-and-pull against each other—and against evolving market tastes and preferences—to create the commercial outcomes we see. These drivers are:

- The industry structure and innovation in the "value chain".
- The plant characteristics and technical innovation in plant cultivation.
- The legal protections for rights and innovation in the law.

This report describes these drivers fully and uses them to develop a snapshot summary on five clusters of activity (which we have loosely described as 'sectors'): (i) agricultural and vegetable crops; (ii) pasture plants and amenity grasses (with fungi); (iii) fruit and nuts; (iv) ornamental plants and trees; and (v) algae. Each of these sectors is dramatically different, from size, structure, and plant characteristics. Each differs in its use of tools to protect rights and generate rewards for innovation.

Much of the information that was disclosed to us by industry participants in this research is commercially sensitive. This report attempts to provide a balance between providing useful information for policy-making and protecting private commercial information.

What is happening in New Zealand plant-based innovation

The review finds that the balance between providing an opportunity for a plant breeder to obtain a reward for their effort in developing a new plant variety, and the benefits to growers and society from having access to new and improved plant varieties, has been reasonably well-set.

We did not see evidence that New Zealand is missing out on new plant varieties as a result of the PVR regime (although many comments were made on challenges associated with the import regime).

While breeders and growers pointed out costs and uncertainties associated with some parts of the system (particularly enforcement, and worries about compulsory licensing), we have observed a relatively healthy, dynamic system for generating new cultivars from within New Zealand. Joint venture arrangements between Crown Research Institutes (CRIs) and private entities have emerged and are

becoming more sophisticated, and these are working to generate and commercialise new plant cultivars. We have observed—on the whole—outcomes that show trust and confidence in New Zealand's systems for protecting plant-related intellectual property (IP). We have seen a combination of legal instruments being used to protect property rights in new plant varieties, including PVRs, contracts and patents. These legal instruments are being used in parallel with industry structure to strengthen the appropriability of plant innovations.

The industry thinks the system is working well, but fraying at the seams

Despite these apparent successes, we spoke with numerous parties who emphasised to us their view that the PVR system is starting to fray at the seams. They told us that New Zealand's legislative settings are starting to introduce uncertainty, which will affect innovation if not addressed soon. We have not seen evidence that this uncertainty is reducing innovative activity, but this does not mean that it does not exist, and the consequences may be yet to materialize. In particular, our legislative settings were seen by many of the people interviewed as:

- lagging the rest of the world by not aligning with the most recent UPOV convention;
- lacking viable enforcement options;
- being constrained in the ability to extend enforcement to unauthorised harvested material (in particular, from offshore);
- uncertain, particularly in regard to compulsory licensing;
- not future-proofed, particularly in regard to evaluation settings; and
- preventing reasonable methods of royalty capture, particularly for farm saved seeds.

The plant-based industries are overwhelmingly supportive of moves to modernise the Plant Variety Rights Act to bring it in line with UPOV 91. A revised Act needs to reflect a new reality in which plant technology is changing, industry structures are changing, and the plant-based industries are among New Zealand's largest producers.

1. Introduction

MBIE commissioned the authors to prepare this report as part of its review of the Plant Variety Rights Act. This report presents an analysis of the innovation systems that sit behind the development and use of plant varieties in New Zealand. It is intended to provide independent, objective information for policy-setting.

This report develops three lines of enquiry:

1. A framework for considering plant-based innovation in context.

2. Information about what is happening behind the scenes in New Zealand's plant-based innovation systems.

3. An evaluation which asks, is New Zealand missing out on better plant varieties, and are our legislative settings to blame? In particular, we were asked to consider the settings around compulsory licensing, rights over harvested material and the ability for farmers to 'save seeds'.

The framework we have developed emphasises the roles that industry structure, plant type and market forces play in determining how an innovation system operates. Thus, the role of intellectual property protection is situated in this context. It is a combination of factors that leads to the outcomes that society wants from innovation.

The evaluation component of this research asks, is New Zealand missing out on better plant varieties, and, if so, are our legislative settings to blame? The views formed in the evaluation build from several sources:

- a comprehensive review of the literature (including trends observed in other, similar jurisdictions)
- a review of comments in industry submissions received by the Ministry of Business, Innovation and Employment (MBIE) in response to its Issues Paper for the Review of the Plant Variety Rights Act 1991
- comments received during 20 interviews we conducted with growers, breeders and marketing organisations of all sizes during March 2019
- analysis of the data in the UPOV plant variety database PLUTO and the New Zealand Intellectual Property Office.

The final chapters present a deep-dive into the issues of Farm Saved Seed, Compulsory Licensing and Harvest Material, building on the dynamics presented in the earlier chapters.

2. Background information

2.1 Plant variety rights are a social contract

The Plant Variety Rights Act 1987 provides legislative IP rights for plant breeders who cultivate plants.[1] Current rights are set out in section 17(1) of the PVR Act and are, "the exclusive right to produce for sale, and sell, reproductive material of a protected variety, or, for vegetatively produced varieties, to propagate them for the commercial production of fruit, flowers, or other products of the variety."

PVRs do not give PVR owners full property rights over plants or other material of their protected varieties. All a PVR confers is a limited right to exclude others from exploiting a protected variety subject to the exceptions and limitations set out in the PVR Act. In this respect, a PVR, like other IP rights, are not the same as other property rights. We would characterise PVRs as a grant of a temporary monopoly, subject to conditions.[2]

At a simple level, plant breeders' rights are a contract between society and a breeder. The contract provides a balance between the opportunity for the plant breeder to obtain a reward for the production of a new plant variety, and the benefits to growers and society from having access to new and improved plant varieties. For example, growers and society benefit by having access to varieties that produce higher yields and/or have better disease and pest resistance, are more environmentally friendly and/or have improved levels of consumer satisfaction. Secondary innovators (that is, the innovators who use the advances made by a prior breeder to create further advances) benefit by having access to varieties for research.

2.2 Plant variety rights underpin five sectors

We were asked to describe and evaluate New Zealand's plant-based innovation system; we have observed not one but in fact five distinct systems. We have described these systems as sectors. They

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[1] PVR protection only extends to cultivated varieties. The international definition of a cultivar is "an assemblage of cultivated plants which is clearly distinguished by any characters and which, when reproduced, retains its distinguishing characters," (International Code of Nomenclature for Cultivated Plants (ICNCP or Cultivated Plant Code)). The most helpful delineation is probably that a cultivar will comprise only a part of the species, botanical variety or other botanical taxon under which it is classified. Seed is the physical embodiment of the invention of the plant breeder which consists traditionally of an iterative process of crossing existing varieties and selecting among the various progeny. The 'invention' is thus the idea of crossing certain varieties, and the resulting progeny, and insight into the possible results of this process. But the resulting variety is also partly a product of nature not necessarily influenced by the breeder. Having access to this information thus does not guarantee that someone else ('a person skilled in the art') will be able to reproduce the same variety. These are some of the considerations that led to the creation of separate criteria for protection for plant varieties, and to a different scope of protection, as compared to patents (Kloppenburg, 1988).

[2] There are many reasons for considering a PVR as a grant. For example, breeders must apply for a PVR and grant can be refused if the variety does not meet the requirements for grant – so any rights given are conditional. The PVR is granted for a limited time, subject to the payment of annual renewal fees. The right can be revoked at any time if the conditions set out in sections 15 and 16 of the PVR Act are not met. The granted PVR is subject to the exceptions set out in section 18 of the Act, which allow use of a protected variety without the permission of the PVR owner.

are: (i) agricultural and vegetable crops; (ii) pasture plants and amenity grasses (with fungi); (iii) fruit and nuts; (vi) ornamental plants and trees; and (v) algae. Each of these sectors is dramatically different, from size, structure, and plant characteristics. Each also differs in its use of tools to protect rights and generate rewards for innovation.

2.3 A snapshot of the PVRs in New Zealand

As at 1 January 2019, there were 1,292 PVRs active in New Zealand

- Agricultural and vegetables crops – 189 (14.6%)
- Fruit and nuts – 245 (19.0%)
- Fungi – 23 (1.8%) (these all appear to be endophytes, related to the pasture plants and amenity grasses sector)
- Ornamental, trees and other plants – 739 (57.2%)
- Pasture Plants and amenity grasses – 96 (7.4%)

Over the past 20 years the average number of new PVR applications has been 146 and the average number of new PVR grants has been 119. For the same period, the number of active PVRs has increased over 50%.

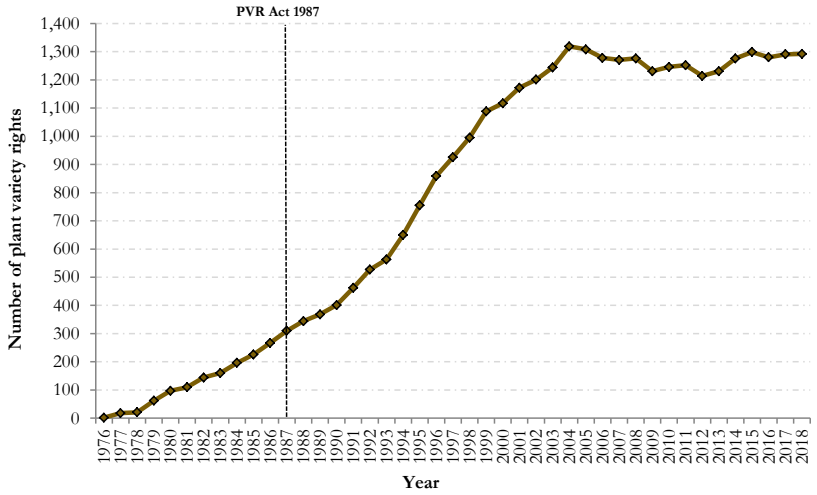
- The average rate of success for PVR applications (1976-2016) is 80.6%
- Agricultural and vegetables crops – 81.7%
- Fruit and nuts – 59.7%
- Fungi – 73.5%
- Ornamental, trees and other plants – 86.0%
- Pasture Plants and amenity grasses – 76.0%

The net number of PVR grants has been more volatile than new PVRs – the covariance of new grants and surrendered + expired grants is significantly positive (i.e. cov(new grants, old grants)). This implies that increases in the number of new grants are positively correlated with increased in the removal of current PVRs. This is true for all variety use types

As at 1 January 2019, 52% of current PVRs were applied for by foreign applicants. This foreign share has been decreasing slowly from its peak of 65% in the mid-90s. Foreign PVR ownership varies considerably between variety use:

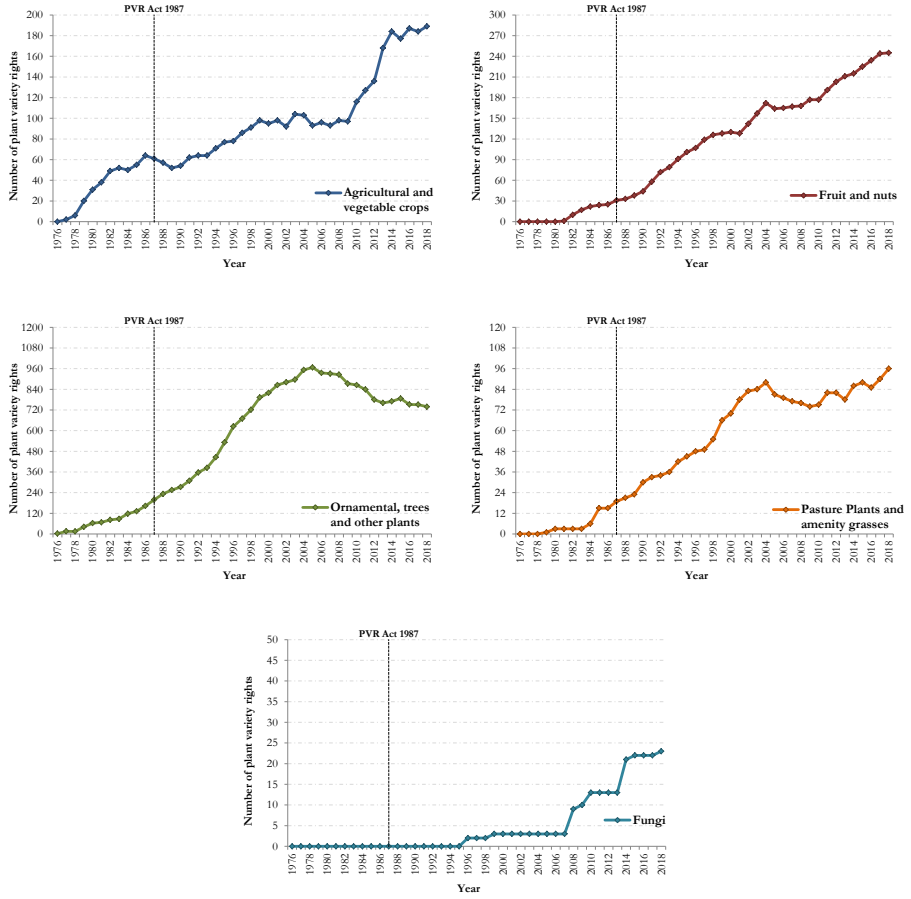
- Agricultural and vegetables crops – 66.1%
- Fruit and nuts – 44.9%
- Fungi – 13.0%
- Ornamental, trees and other plants – 56.6%
- Pasture Plants and amenity grasses – 16.7%

Figure 1 Active PVRs in New Zealand per annum: 1976-2018



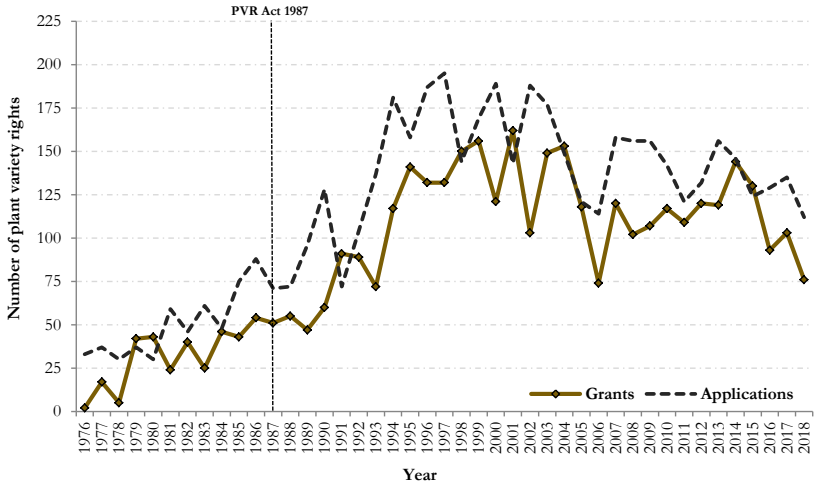
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 2 Active PVRs per annum by variety use: 1976-2018



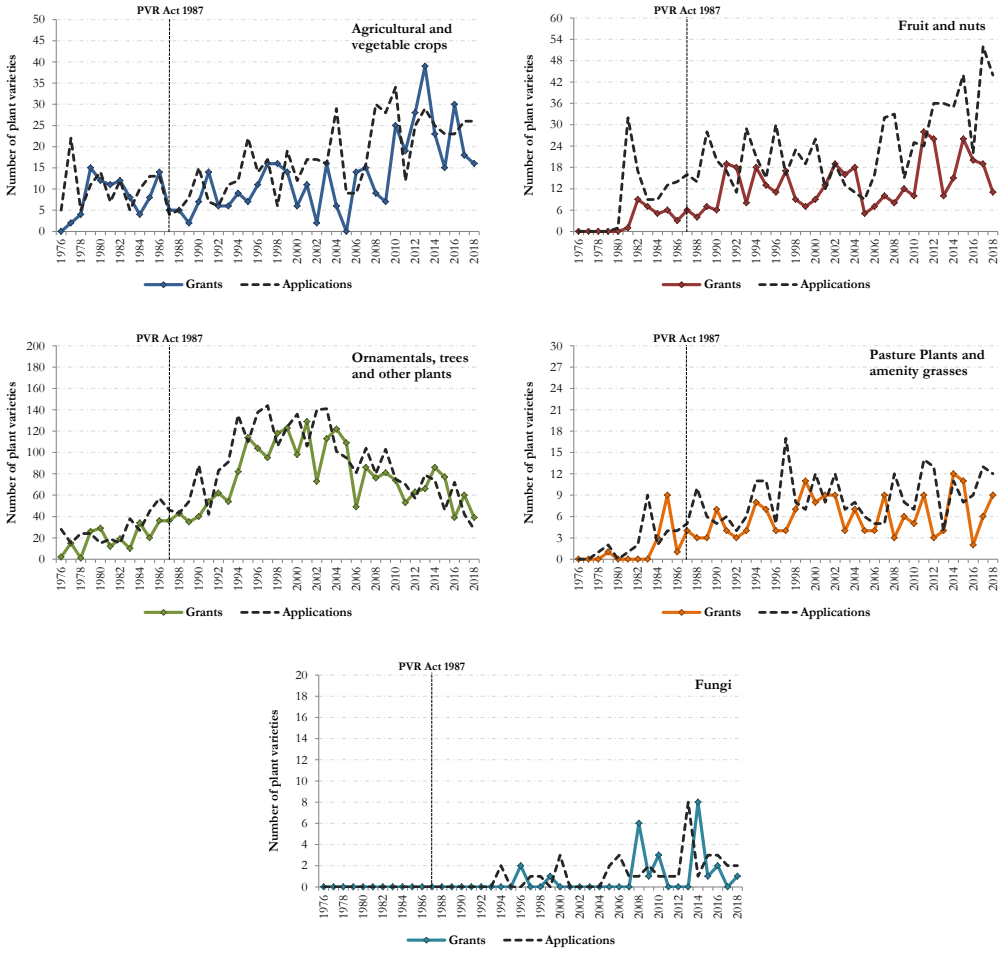
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 3 PVR applications and grants per annum: 1976-2018



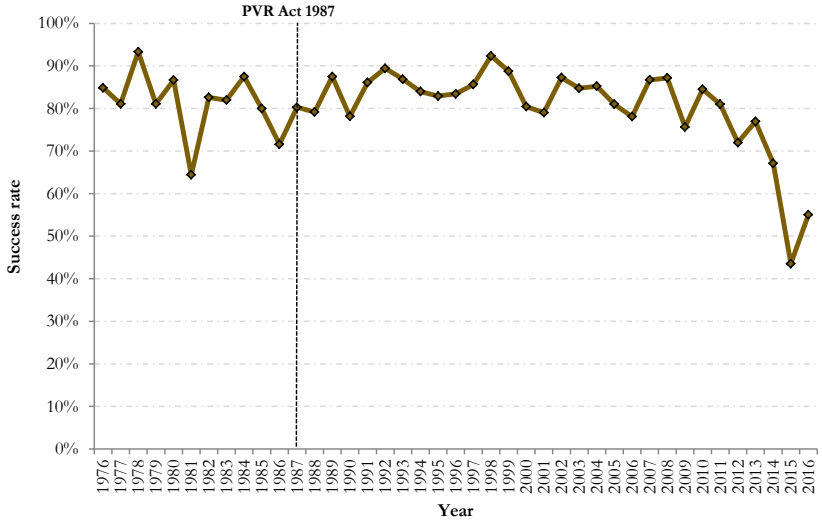
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 4 PVR applications and grants per annum by variety use: 1976-2018



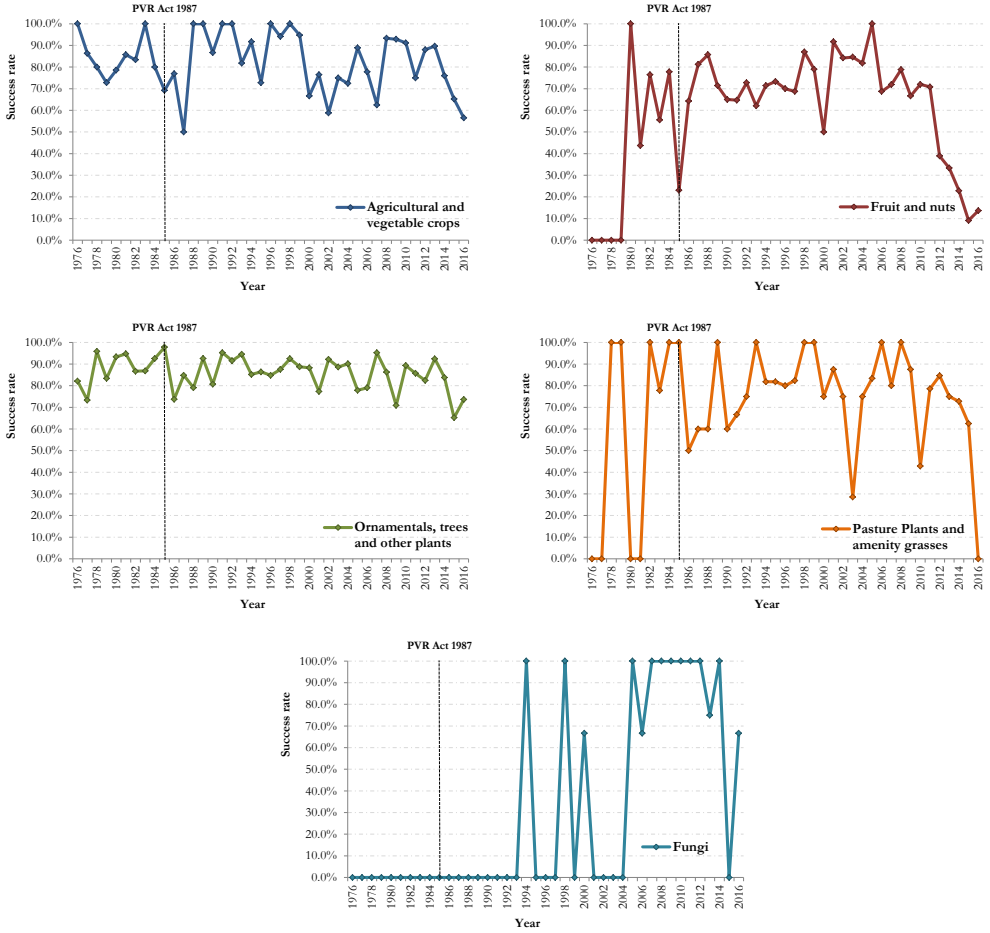
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 5 Rate of PVR application success: 1976-2016



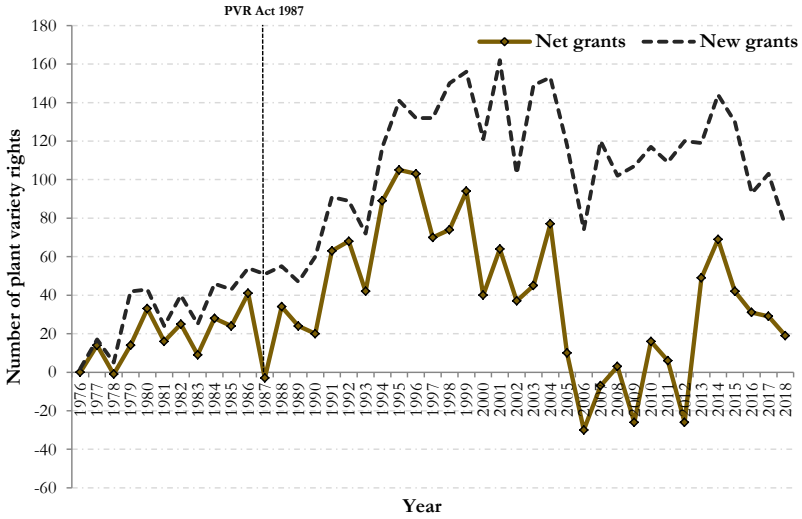
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 6 Rate of PVR application success by variety use: 1976-2016



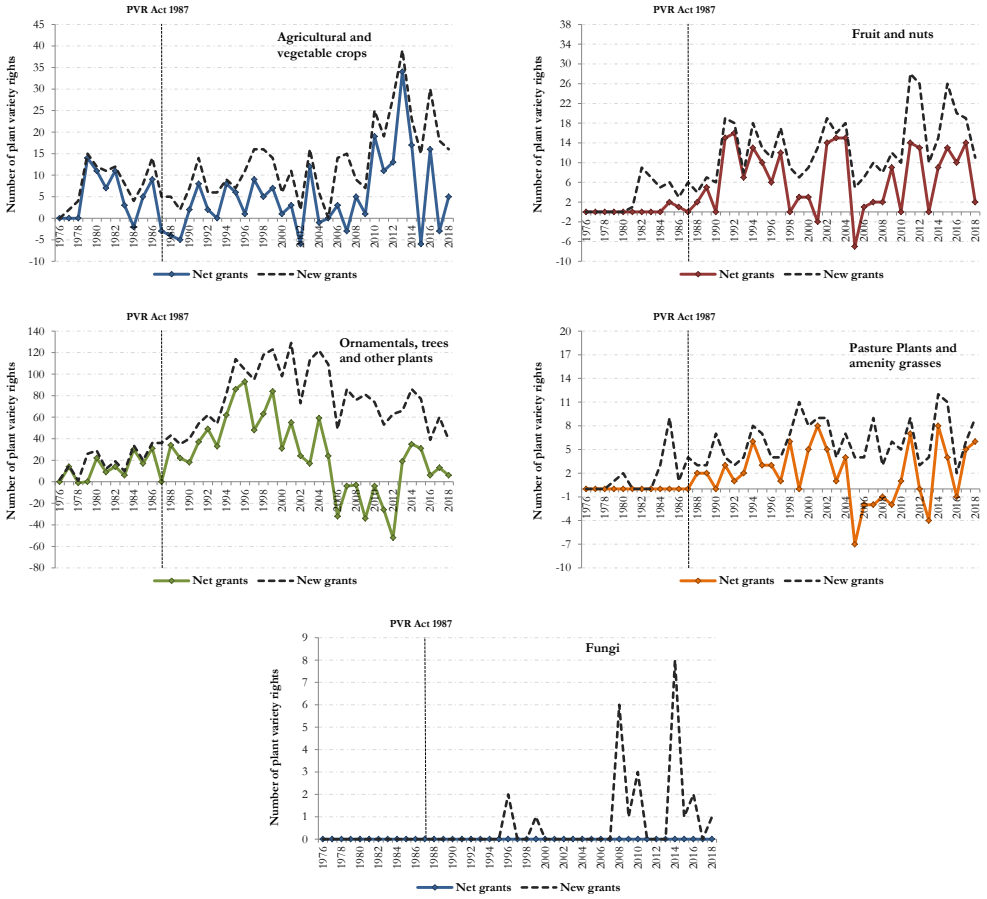
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 7 PVR counts & net grants: 1976-2018



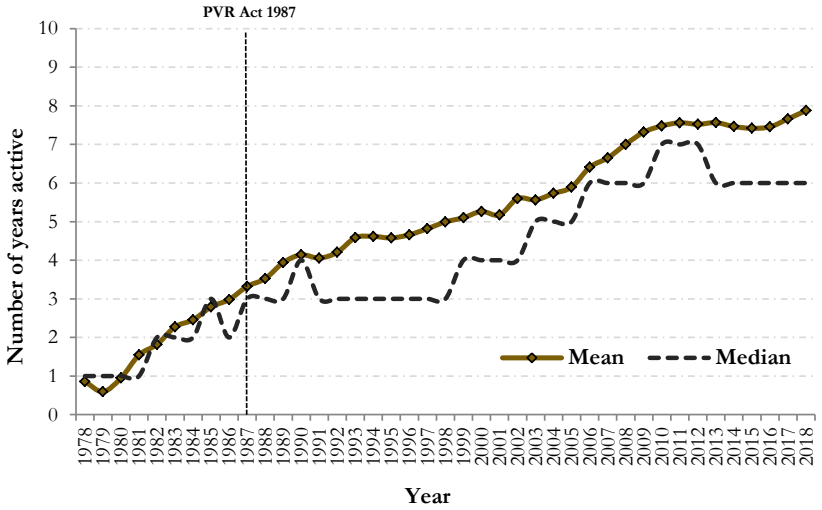
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 8 PVR counts & net grants by variety: 1976-2018



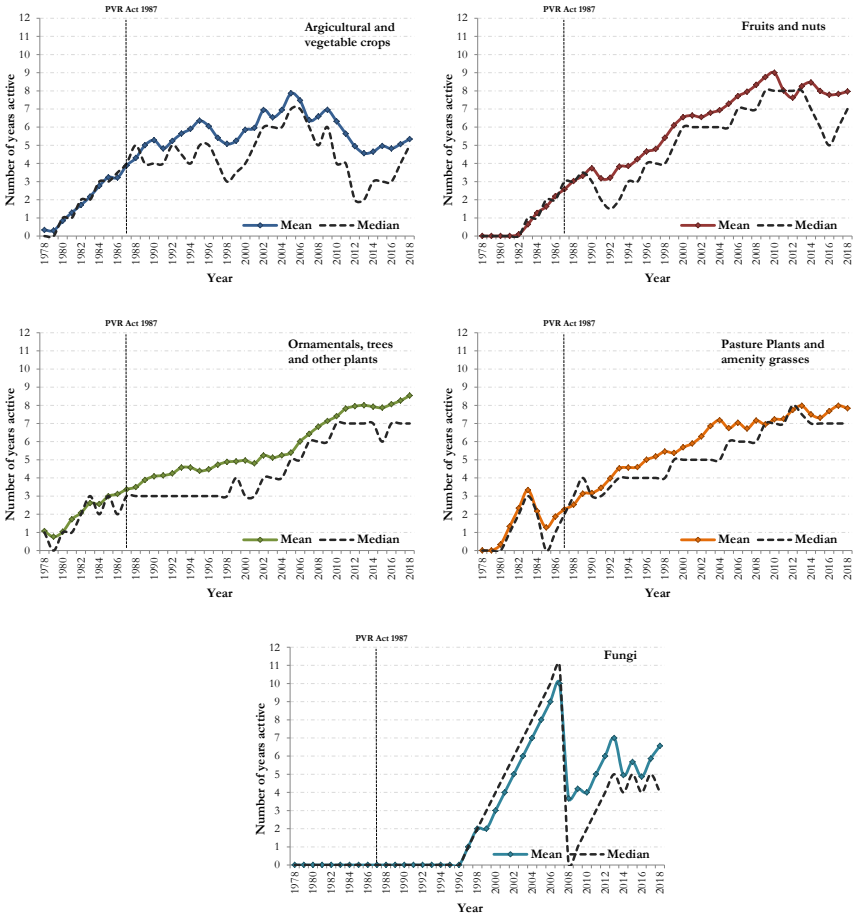
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 9 Mean length of current PVRs per annum: 1978-2018



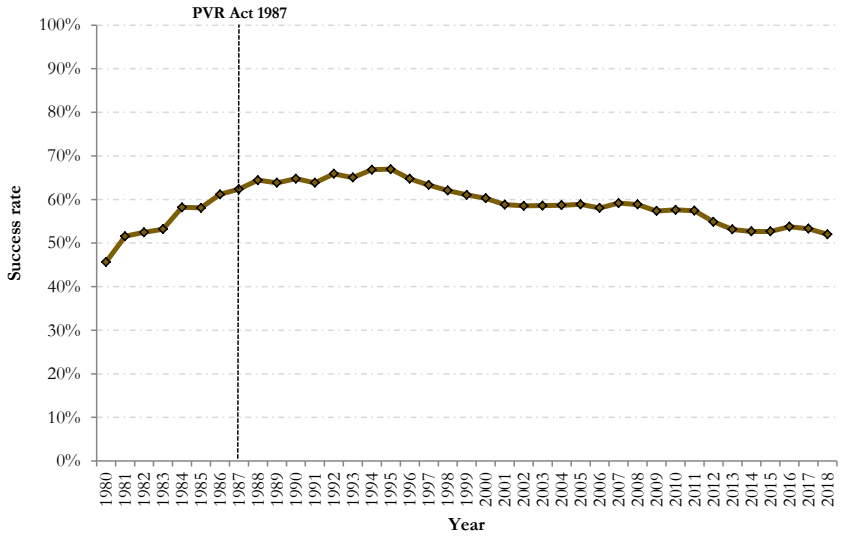
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 10 Mean length of PVR stock by variety use per annum: 1978-2018



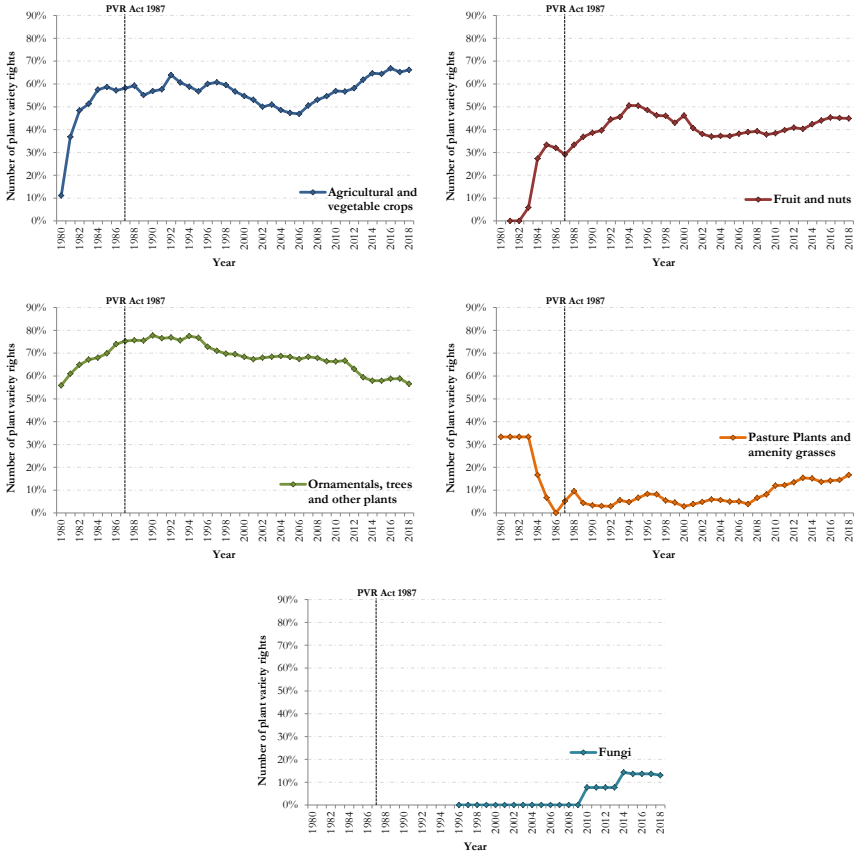
Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 11 Percentage of PVRs held by foreign applicants per annum: 1980-2018



Source: Sapere analysis, Intellectual Property Office New Zealand

Figure 12 Percentage of PVRs held by foreign applicants by variety use per annum: 1980-2018



Source: Sapere analysis, Intellectual Property Office New Zealand

3. A framework for understanding plant-based innovation

Innovation is the engine of long-run growth. However, innovation does not flourish in isolation, but it is the result of the interactions among firms, policy-makers, and the institutions that shape the environment where firms innovate. Among the institutions that matter for innovation, the legal system for the protection of the intellectual property (IP) has a prominent role and unsurprisingly, its design has been one of the main concerns of the innovation and technology policy across the world. A welfare-enhancing legal system for the protection of the IP must balance different requirements (Nordhaus, 1969).

On the one hand, IP law must allow inventors to benefit from their investment by letting them appropriate some of the returns from their inventions. On the other hand, it must do so in such a way that the social costs associated with the creation of a (possibly short-term) legal monopoly are minimised while not hindering the diffusion of the newly created knowledge across the economic system (Levin et al. 1987, Gallini 2002, Kultti, Takalo, and Toikka 2007).

3.1 Two types of innovation, primary and secondary

Technical and scientific progress is sequential in most industries, so that today's inventions are not only the origin of new technologies and products but also the starting point of future innovation. An original invention makes follow-on inventions possible. The issue of the subsequent innovation has been the subject of much thought (for example, Ducor 1997). One conclusion often reached is that no system will grant both the initial innovator and the follow-on innovator adequate incentives to innovate. This is so because to compensate the original innovator for the positive externality he creates, he must receive a part of the surplus originated by the follow-on innovations. However, to give those follow-on innovators an adequate incentive, they must get the entire surplus created by their innovations. So, a choice has to be made to solve this "egg and chicken" problem.

Thus PVRs, like other forms of IP, attempt to balance two different types of innovation, primary and secondary. Empirical studies have yielded inconclusive results concerning the net effect of patent breadth on both types of innovation taken together (OECD, 1997), so setting this balance is difficult to achieve with certainty. The difficulty is that whilst broader rights will typically translate into greater rewards to primary innovators, they simultaneously tend to increase the costs and uncertainties facing secondary innovators.

3.2 Plant variety rights gives a breeder 'appropriability'

The challenge for an inventor (or plant breeder) who wants to profit from their effort is how to give that invention 'strong appropriability' (Teece, 1986). Put simply, this means that inventors and investors try to find ways to commercialise their invention but at the same time protect the invention

from being taken and used by others.[3] If the prospect of profit is a principal factor motivating innovative activity, then strong appropriability for the primary innovator should lead to high levels of research, development, and innovation. The economic literature on plant breeders' rights emphasises the characteristics of plants that make them vulnerable to being taken and used by others (that is, plant varieties without IP protection from the legal system, have weak appropriability). The literature theorises that plant innovations are unique and warrant their own systems for IP protection.[4]

So, the theory goes that using the law to give cultivated plant varieties high appropriability may encourage a high rate of innovation and economic growth (at least, in primary innovation). Yet, there are risks to awarding all the appropriability to the primary innovator. To give exclusive, unrestricted rights to the original innovator risks creating the "hold-up" effect.[5] Other arguments point out to concerns that the original broad rights can be used to raise high barriers to entry because of high licence fees or fear by new entrants of expensive rights infringement litigation. In addition, in cases where basic research is encouraged by public funding (such as New Zealand's Crown Research Institute funding), some authors argue that setting IP rights too strong may create a barrier to applied research which is not offset by better incentives for basic research (Barton, 1996).

In general, the majority of authors appear to be of the opinion that it is the first innovator who should receive the greater benefit but that subsequent innovators should have some legal protection. The PVR Act provides protections for subsequent innovators in three ways:

1. It places restrictions on what can be granted a PVR (for example, only cultivated varieties that demonstrate characteristics that make them distinct, uniform and stable).

2. It has a 'Breeder's Exception' which allows breeders to use the variety for breeding new varieties.

3. It allows for compulsory licensing, under certain conditions.

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[3] Appropriability is the ability of the innovating firm to protect its technology from competitors and to obtain economic benefits from that technology. The origins of the empirical literature on the subject can be traced back to the seminal works on patents by Scherer et al (1959) and Mansfield et al (1981). However, a key turning point took place in the mid-1980s when Teece (1986) established a new theoretical framework for analysing the relation between innovation and appropriability and Levin et al (1987) studied how firms used a variety of different appropriability strategies including, but not limited to, patents.

[4] A new plant variety is somewhat different from many other innovations. In terms of its characteristics as an economic good, a new plant variety is partly non-rival and excludable. The tissue cultivars of a new variety can only be used by one person at a time, and thus has some of the nature of a rival good. But because a plant is self-reproducing, replicating the seed or tissues can be undertaken at very low cost, and indeed use entails replication. Thus, the seed/tissue cultivars can be considered as partly non-rival. On the other hand, it is generally possible to exclude someone from using the seed/tissue cultivars by taking measures to regulate access to the seed. The legislative regulation of access to the seed is what is provided for in the Plant Variety Rights Act. Other ways of regulating access to the seed/tissue cultivars include contract and vertical integration.

[5] The fear of "hold-up" results from the fact that an improvement of an original invention which is within the claims of that original innovation could not be marketed unless the holder of the original property right agrees. In cases where the negotiation is carried out after the second innovator has made substantial investments to develop the improvement, his position will be completely dependent on the first innovator which could use his privileged position to get a part of the value created by the improvement. In such cases, the second firm's investment decisions must be tempered by the risk that the negotiations will not turn out well.

The presence of these protections suggests that PVRs are not granted in the abstract; rather, they are given on the understanding that the PVR holder will fill the market with the protected variety for the benefit of consumers. That is, there is an implied 'contract' between state and the PVR holder, in which the PVR holder agrees not to unreasonably withhold the plant variety for the benefit of society. This perhaps gives weight to the broader claim that PVRs must be tied to their theoretical justification, and if they are not, they may be curtailed. That is, if the balance between the opportunity for the plant breeder to obtain a reward for the production of a new plant variety, and the benefits to growers and society from having access to new and improved plant varieties, is no longer balanced then rights can be justifiably curtailed.

Breeders (and their investors) use strategies other than PVRs for increasing appropriability. The two most important strategies have been the use of hybrid technology (which is now extending into plants like potatoes) and contracts with other breeders, seed producers, farmers and those further along the marketing chain. Patents (for example, of endophyte-related processes) are also used as specialised complementary assets to PVRs.

3.3 Competing interests try to influence PVR law for their benefit

People and entities who operate in an innovation system seek to influence that system for their own benefit (Graff and Zilberman, 2007; Brousseau, Garrouste and Raynaud, 2011).[6] In a plant-based innovation system, those seeking to influence the system include individuals and organizations involved in research and development (R&D) in biotechnology and plant breeding, in both the public sector (CRIs) and the private sector. Those in R&D can be further categorised into primary innovators and secondary innovators. Alongside those in R&D are seed propagators, farmers, other businesses involved in the agricultural or horticultural value chain, Crown Research Institutes and industry-funded research organisations, and others. These agents of change attempt to influence IP law, including legislation like the Plant Variety Rights Act.

3.4 Mutually reinforcing drivers of the innovation system

The drivers of plant-based innovation can be summarised into three, mutually-reinforcing drivers. These drivers are:

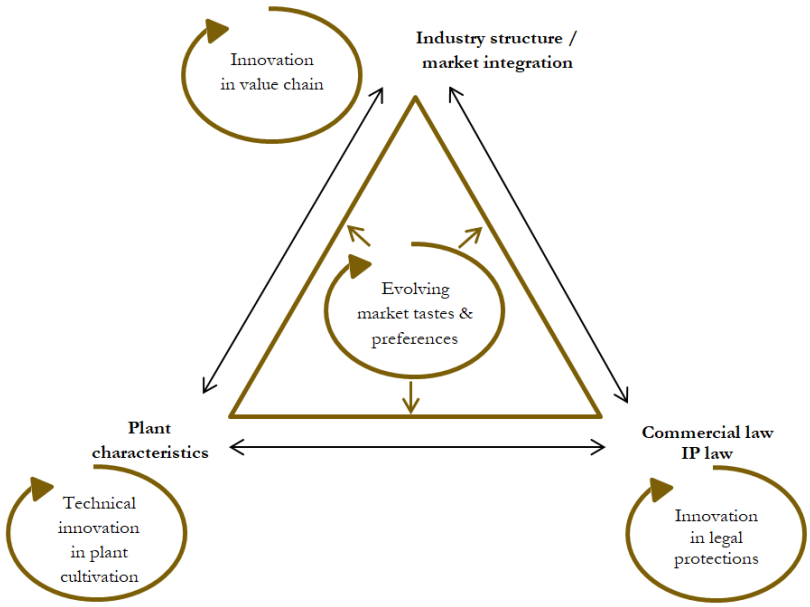
- The industry structure and innovation in the "value chain"
- The plant characteristics and technical innovation in plant cultivation

[6] Any informative perspective on innovation for policy purposes should recognise that there are different interests involved in considerations of IP policy. This can be seen in some of the earlier contributions in the economic literature, which emphasised differences between consumers and innovators interests (Arrow, 1959; Nordhaus, 1969a). As literature has developed, the configuration of interests analysed has become more complex, incorporating differences between innovators, possibly competing with each other and also different groups of consumers. Heterogeneity of interests and of effects is a recurrent theme in this thesis, in both theoretical and empirical analysis.

- The legal protections for rights and innovation in the law

All are influenced by evolving market tastes and preferences. We have summarised these forces in Figure 1 below:

Figure 13 Mutually reinforcing drivers of plant innovation



Source: Sapere Research Group

3.5 The first driver, industry structure (industrial systems)

The development of new cultivars cannot be considered without considering the industry's capacity for appropriating returns on investments made in biotechnology and plant breeding. Industrial systems and industry structure are key to the ability to channel profits back to breeders and into new investments.[7] Industrial structures, in turn, are greatly affected by the legal settings and the characteristics of the plant itself, but we will turn to these later in the text.

Schumpeter (1943) was the first to show that market structure influences the pace of innovation (Sweezy, 1943). He went on to say that large monopolistic firms are ideally suited for introducing technology innovations that benefit society. Since his seminal work, a lot of theoretical and empirical effort has been devoted to examine Schumpeter's assertions. Nowadays, it is generally agreed, that up to a point, an increased number of competing firms in a market stimulates more rapid and intense support of R&D....But when the number of firms becomes so large that no individual firm can appropriate quasi rents [profits] sufficient to cover its R&D costs, innovation can be slowed or even brought to a halt.

[7] By industry structure, we mean the number and size distribution of competitors in an industry. Some industries, such as the crop seed industry, contain many firms or competitors. Other industries, such as the kiwifruit industry, contain relatively few competitors.

So, some degree of market power will be preferable to perfect competition for fostering innovation, especially in cases where advances in the knowledge base occur slowly. But, a high level of market power will retard progress, especially in areas where technological progress is quick. This is because high market power restricts the number of independent sources of innovation and dampens firms' incentives to gain market share through accelerated R&D.

Vertical integration is used as a strategy for capturing value across the whole value chain

Globally, there has been a sustained trend in the plant industries of using industry structure as a means of gaining appropriability over not only the plant-based innovation but over the rest of the value-chain (growing, harvesting and marketing). The ability to control quality and supply of a plant-based product is a complementary asset to the ownership of intellectual property in the plant. This has implications for market power, and has effects on the rate or direction of innovation in the breeding sector (Graff et al., 2003b,a, 2009; Goeschl and Swanson, 2003).

The relationship between intellectual property in a new plant variety and complementary assets (like being able to control the supply into the market) is outlined in Teece (1986). This seminal paper demonstrates that when there is weak appropriability (i.e. when there is a limited ability for the innovator to protect their invention from competitors), markets don't work well at sustaining value, and the profits from innovation may accrue to the owners of certain complementary assets, rather than to the developers of the intellectual property. This speaks to the need, in certain cases, for the innovating firm to establish a prior position in these complementary assets before investing in innovating activities. The paper explains that trying to coordinate complementary assets (like marketing and consistency of supply) is transaction-cost heavy and leads to uncertainties that can be crippling for an industry. For example, an apple grower deciding to plant a newly-developed apple variety may be dissuaded by uncertainty around how the apple will be sold and the returns she will get if the market if her neighbours under-cut her prices and the supply becomes commoditised.[8,9]

Sometimes, innovators with new products and processes which provide value to consumers may sometimes be so ill positioned in the market that they simply cannot make profit, and subsequently fail. For example, the New Zealand Apple and Pear Marketing Board failed to maintain a brand presence in export markets and conduct appropriate control of the fruit varieties from grower to consumer, which led to its eventual collapse in the late 1990s.[10] Then the Apple and Pear quality mark

[8] As an example of a tendency toward commoditisation, in the 1980s countries other than New Zealand began to export kiwifruit, and New Zealand lost its first-mover advantage with the Hayward variety. The seven licensed exporters in New Zealand were in fierce competition, driving down prices. This reduced grower profitability and caused fluctuations in both supply and demand.

[9] Some of the success of the kiwifruit sector was due to a first-mover advantage. This advantage was gained due to the commoditisation of Hayward (green kiwifruit not controlled under licence) as it provided market penetration and customer familiarity across the world. Later plant varieties such as Hort 16A and G3 benefited from the earlier commodification of Hayward as they arrived in established markets for kiwifruit.

[10] For example, the restructuring documents published by the New Zealand government in the late 1990s emphasise problems with bureaucratic control over supply and a thriving black market in counterfeit fruit. From the mid-1990s there was increasing pressure to deregulate the pipfruit industry, and the Apple and Pear Board's selling monopoly was removed in 2001.

emerged once growers bought the IP to the fruit varieties. A greater investment in branding sat alongside sustained efforts in developing newer, desirable varieties for export markets. Now, the New Zealand apple industry is the most competitive in the world.[11] This part of our apple growing history supports the argument that innovators often need to integrate with owners of complementary assets before they can profit from innovation. This is also evidenced by joint venture arrangements which set up companies that combine plant innovations (like new ryegrass varieties) with complementary assets (like large grass seed companies, who have the path to market).

Teece (1986) explains why globally since the 1990s there has been increased vertical integration between plant breeding activities, grower activities and market-facing activities, and in some plant-based industries, industry concentration in a smaller number of firms. This evolution has been due to the need for innovators to have related competencies to capture the value from their innovation. These competencies include the ability to generate scale and to market/brand your product to be appealing to customers. So innovators with the best ability to generate new plant varieties may not succeed, they need to integrate or coordinate with others (Teece, 1986). Vertical integration is a complementary pillar to intellectual property protection when it comes to protecting value for inventors and the owners of specialised complementary assets.

Figure 14 The Teece framework for understanding appropriability regimes

	Limited IP protection (weak appropriability)	**Comprehensive IP protection (strong appropriability)**
Generic complementary assets	Consumers capture most of the value (e.g. better plants)	Innovator captures most of the value (e.g high royalties to inventor)
Specialised complementary assets	Innovator captures minority share of value (e.g. offshore supermarket chain captures profits from apple variety)	Innovator and owners of specialised assets share value (e.g. vertical integration between CRIs, growers and brand-owners)

Source: David Teece (1986)

Looking to New Zealand, evidence of this global trend towards vertical integration alongside IP protection is everywhere. This suggests that appropriability is reasonably strong (and IP is reasonably strong) and complementary assets are specialised (that is, there needs to be investment in the 'path to market' alongside investment in new varieties). Zespri and Fonterra are two obvious examples; both are statutory monopsonies with full vertical integration (and long-term JV contracts with research organisations plus internal R&D programmes). Other examples in the plant industry include the fruit sector, where there are numerous examples of attempts to use IP and grower-contracts to capture the supply chain into a branded good. The 'capture' strategy is to develop and protect IP for the fruit variety, then use a combination of vertical integration and contracts to provide an end-to-end path to

[11] The *World Apple Review* for the fourth year running named New Zealand's apple industry the most competitive on the global stage, out of 33 countries (2018).

export markets (where the benefit to the seller is that it can offer brand, scale and supply consistency, the benefit to the grower is price, and the benefit to the breeder is sustained returns to innovation).

There are downsides to vertical integration and the concentration of market power. For example, market power may mean that New Zealand consumers are charged high prices. Dense industry concentrations can sometimes drown out or capture 'outsider' innovations or squeeze out growers who are outside the integrated entity. This explains the protections for growers in industry regulations like the Kiwifruit Export Regulations and protections for consumers and others in the Commerce Act. In the PVR Act, there are provisions to protect 'outsider' breeders like the breeders' exemption and the compulsory licensing provisions.

Increasing privatisation of research

Globally, the trend in plant-based R&D has been characterized by an ebbing public sector and a rising private sector (Jefferson, D. J., & Padmanabhan, M. S. (2016)). That is, many aspects of plant research have been relinquished by the public sector and handed over to the private sector. This trend is perhaps a consequence of stronger IP rights for plant innovations from PVRs.

In the past, scientific advancement in agricultural or horticultural technologies was a public goods issue. Public sector institutions and universities acted as the primary drivers of research and development ('R&D'), and their resulting products (e.g., new crop varieties) were transferred directly to farmers. While this model persists in many world regions, changes to IP laws, that broadened the ambit of protectable subject matter, have resulted in a substantially greater role played by private sector entities in agricultural R&D (Jefferson, D. J., & Padmanabhan, M. S. (2016)).

This shift from public to private action has been especially true in the realm of ag-biotech, given the significant financial and temporal investments required to develop new biotechnologies and steward them through complicated regulatory frameworks. As such, it is now impossible to consider the relationship between IP rights and agbiotech R&D without comprehending the impact of regulatory regimes on this sector. Notwithstanding the high costs associated with the effective commercialisation of agricultural biotechnologies, the contemporary innovation system requires a balance of exclusive (private) and non-exclusive (public) access to proprietary technologies to effectively support new crop development. An equilibrium between public and private is also critical to provide commercial growers the best genetic technology possible to cultivate productive, nutritious, and marketable crops.

When research is privatised, the costs of developing new plant varieties are internalized by those who stand to profit from the research findings, rather than being spread across all societal groups through general tax funding. Privatisation of research is efficient because the economic returns to characteristics that that the market finds favourable (for example, crunchiness in apples) can be bred into varieties without investment from the public, because there is potential for profit if the research is successful.

We do not have specific evidence for the degree of privatisation of plant-based research that has happened in New Zealand. We can however observe that in the last 10-15 years New Zealand has

developed different 'layers' of research activity, and these layers reflect whether research can be 'commercialised'. For example, we have been told that (CRI researcher, interview 2019) –

- Public, taxpayer funding for research (through CRIs for example) is being directed towards the long-term horizon and toward the "more risky" propositions.
- Joint ventures between Crown Research Institutes and commercial entities are more common when a new discovery is being tested for its commercial application (this is a medium-term horizon).
- Private research tends to be focussed more often on the commercialisation of a variety, its market characteristics (the shorter-term horizon).
- Levy, (or industry-funded research) appears to be focussed on ensuring that growers and farmers have transparency over the performance of a variety, for example with testing and benchmarking (this occurs both pre- and post-commercialisation of a variety).

3.6 The second driver, plant characteristics

Plant characteristics are essential to understanding the innovation system in context. For example, is it quick to grow, can its properties be easily copied and grown by others, is it classifiable as a new cultivar in PVR law, does it exhibit characteristics that meet with customer approval?

Technical innovation is driving IP change

Technical innovations globally since the 1990s include advances in hybrid technology, genomics, genetic modification (in some jurisdictions where it is allowed), and advances in fungi (endophyte) and algal species. Honey is also an emerging product with plant characteristics at its core.

Hybrid plants are interesting because the plant itself provides the appropriability.[12] For example, most commercial corn varieties are hybrid. This means that seed from a new corn variety cannot be multiplied without marked failures in quality due essentially, to in-breeding. This provides a strong incentive for growers and others not to multiply and sell the seed from corn.

Increased concentration in marketing and growing, but not in relation to breeding

The extent to which PVRs are concentrated by fewer firms differs between sectors. Table 1 below illustrates.

[12] It is worth noting, however, that the extent of appropriability that can be achieved using hybridization varies considerably depending on the biological characteristics of specific crop species, with general distinctions being drawn between cross-fertilizing (most amenable to hybridization), self-fertilizing, and vegetatively-propagated species (in descending order of the ease with which the crops can be protected by biological means).

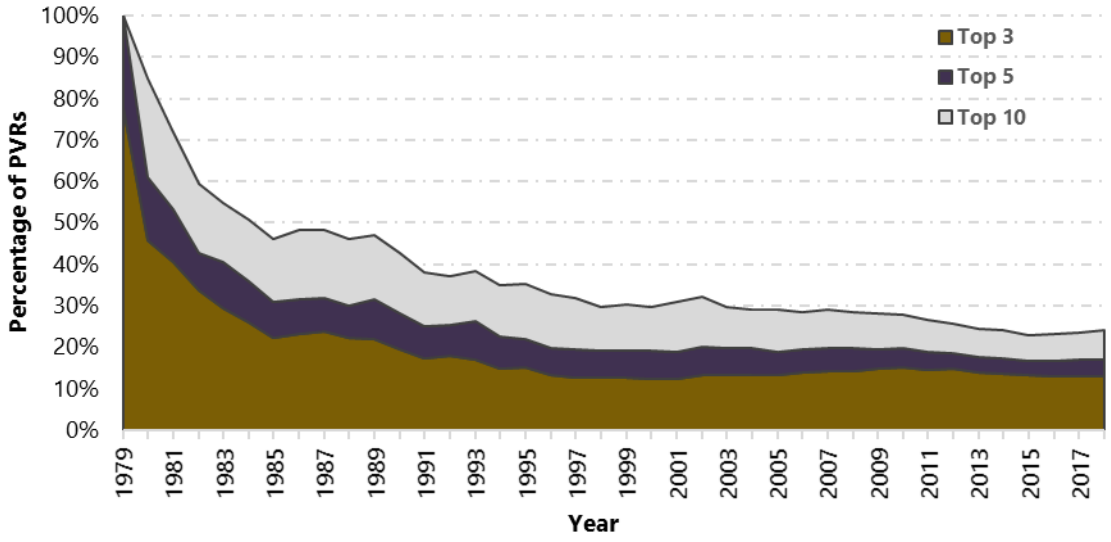
Table 1 PVR concentration — by industry

As at 1 January 2019	Top 3 firms	Top 5 firms	Top 10 firms
Agriculture and vegetable crops	32.3%	41.8%	58.2%
Pasture plants and amenity grasses	56.3%	75.0%	90.1%
Fruit and nuts	34.7%	41.2%	53.1%
Ornamentals, tress and other plants	12.0%	17.1%	26.4%
Fungi	87.0%	100.0%	100.0%

Source: Sapere analysis, Intellectual Property Office New Zealand

In the last fifteen years there has been increased industry concentration in relation to marketing and growing, particularly in fruit, arable seeds and pastoral grasses (according to qualitative comments made in almost all of our interviews). But this trend does not appear to have carried on to breeding. For example, PVR rights are not owned by fewer firms than they used to be fifteen years ago (see Figure 15 below). We are not sure why not, but it could be because of the 'public good' characteristics of some types of breeding and research, which means that publicly-funded CRIs continue to play a leading role in research.

Figure 15 Annual concentration of PVRs by individual owners (1979-2018)



Source: Sapere analysis, Intellectual Property Office New Zealand

3.7 The third driver, legal and social institutions

A combination of legal instruments is used to strengthen appropriability and direct more returns to plant innovators. This includes international treaties like UPOV (to the extent they are implemented in national legislation), PVR legislation in other countries, patents legislation (which plays a complementary role), contract legislation, and common law precedent. The institutions for PVRs include the Intellectual Property Office of NZ (IPONZ) (who investigate applications) and the Commissioner of Plant Variety rights (who grants PVRs and sets the conditions for compulsory licenses). A further set of legal instruments is used to control the effects of having granted exclusive

rights on market power. This includes PVR legislation, competition legislation like the Commerce Act, industry legislation like the Kiwifruit Export Regulations, and common law precedent.

These legal instruments evolve. In examining the forces that cause these legal instruments to evolve, a distinction can be made between legislators (define and create legal instruments), regulators or administrators (IP-granting authorities, who interpret and implement instruments) and the judiciary (interpret legal instruments as a result of conflicts). Each set has slightly different interests, for example at an international level, legislators are affected by international trends and international trade negotiations; the judiciary will be influenced by trends in local social norms or in common law precedents; the administration will be influence by changes in the prevailing legislation in the jurisdiction and practical considerations like budget and capabilities.

Legal institutions for protecting plant breeders' rights operate in the context of the wider legal system

Business law provides a wider context for PVR legislation, and this too evolves over time. In New Zealand since the 1990s, business law has largely evolved in a way that supports a capitalised, free-market, export-led economy. Over the last 30 years our economy has gone from being one of the most regulated in the OECD to one of the least regulated, most free-market based economies. Consequently, New Zealand has a mixed economy which operates on free market principles. It has sizeable manufacturing and service sectors complementing a highly efficient agricultural sector. Exports of goods and services account for around one third of real expenditure GDP.[13] Evolution of New Zealand's agricultural and export sectors has therefore concentrated into more valuable crops. So, we have seen a decrease in (relatively low profitability) ornamental species and an increase in (relatively high profitability) ryegrass and fruit species. This is evidenced in the sector statistics we present in the following chapters.

In recognition of the role that exports play in generating social wellbeing, business law in New Zealand has evolved in the last 30 years to legislate for industry monopsony arrangements (like Zespri) which allow for consumer protections in the home market but provide for scale in export markets. In other instances, industry monopsonies have been rejected by farmer-growers (like Apple and Pear Marketing Board) but other forms of clustering and branding have emerged as industry-led responses to try to tackle the scale problem.

Social arrangements affect the law

Social arrangements also affect what happens in practice. For example, the degree of 'honesty' or integrity in a social setting will impact greatly on the need to use threats of legal intervention to enforce the rights set out in PVRs or contracts. One example of social settings affecting legal settings can be seen in the wheat industry in the South Island. This industry is relatively small, and the growers and seed suppliers are known to one another. Because there are established relationships between seed suppliers and growers, it is easier to govern instances of 'cheating' (for example, where a farmer multiplies and sells a licensed variety without permission or without paying a royalty). The closeness of the industry provides a means of governing 'cheating' through social obligations rather than using

[13] New Zealand Treasury website www.treasury.govt.nz

formal systems like PVR enforcement. If the industry context was different – say there were more growers who were more dispersed and more anonymous – then one would expect to see more formal means of PVR enforcement.

Rules of thumb are used to determine royalties

The royalties paid to breeders are determined by rules of thumb and mutual expectations about what is fair. The shared philosophical view we have observed during interviews is that it is reasonable for an breeder's capability to be rewarded, but how much is paid to breeders is very context dependent. In most cases, royalty arrangements are commercially sensitive, so we have not detailed them here. However, we are aware that some royalty arrangements are negotiated using a rule of thumb that originated with the Licensing Executive Society. This rule of thumb is that 25 per cent of the commercial value generated by an invention (like a crop variety) should come back to the inventor and stakeholder investors. This rule of thumb is over 40 years old, and its use continues.[14] It has been called "the most famous heuristic, or rule of thumb, for licensing valuation."[15] The rule has prevailed because it provides a useful focal point for negotiation.

International expectations drive change too

Lastly, change in the legal system is driven by the needs of the various international parties who invest in New Zealand's plant innovations (as at 1 January 2019, 52 per cent of current PVRs were granted for by foreign entities). Often, international partners are influenced by expectations for intellectual property protection established through international conventions like the UPOV conventions. They will also have expectations formed from their experiences of property rights protection in their home countries.

3.8 Conclusion

The drivers of plant-based innovation can be summarised into three, mutually-reinforcing drivers. Each driver 'evolves' and changes over time. These drivers are:

- The industry structure and innovation in the "value chain"
- The plant characteristics and technical innovation in plant cultivation
- The legal protections for rights and innovation in the law

[14] Use of this rule prevails even after being rejected by the US Supreme Court as a useful methodology for estimating damages in licensing cases. In 2011 the 25 per cent return rule of thumb was rejected by US Court of Appeals for the Federal Circuit as being an adequate methodology for calculating a base royalty rate. The Court held that "the 25 percent rule of thumb is a fundamentally flawed tool for determining a baseline royalty rate in a hypothetical negotiation." Consequently, evidence relying on the 25 per cent rule of thumb was inadmissible under Daubert and the Federal Rules of Evidence, because it fails to tie a reasonable royalty base to the facts of the case at issue. See (https://patentlyo.com/patent/2011/01/uniloc-v-microsoft-the-25-percent-rule-of-thumb-is-no-more.html)

[15] For further explanation of this rule see https://lawexplores.com/use-of-the-twenty-five-percent-rule-in-valuing-intellectual-property/#ch03en6

4. Summary tables

Innovation systems can be mapped in different ways. Appendix B summarises some of the approaches that are used to picture innovation systems. While these approaches have conceptual appeal, they can be complex to read and digest. So in the following chapters we have opted for a simplified approach. We have presented a summary table for each industry.

Each table includes information on:

- Breeding activity and financial flows
- Industry structure
- Plant characteristics
- Legal and social institutions
- Characteristics of market demand.

The table includes information on the current state (what is happening now) and evolution (the direction of change). All the rows in this table are important: they recognise the roles that industry structure, plant type and market forces play in determining how each innovation system operates.

The arrangements that are used can be highly commercially sensitive. Aware that this report might be published, we have tried to make an appropriate balance between providing sufficient information to be useful, and not providing so much information as to be harmful to private commercial interests.

4.1 Agricultural and vegetable crops

This sector includes milling wheat, feed wheat, barley, peas, oats, forage brassicas and seed multiplication, vegetable seeds (like potatoes, corn, carrots)

Breeding activity and financial flows	
Current state	**Breeders and researchers** There are approximately 10 private seed and cereal grain companies operating private breeding programmes, with one being significantly larger than the others. Plant and Food Research (a publicly funded CRI) has been very active in the cereals sector. It has released 15 wheat cultivars, 8 barley cultivars, 3 triticale cultivars and 3 oat cultivars.[16] In addition, Plant and Food Research is doing general research, with Lincoln and Massey Universities providing expertise and support in agronomy (soil science). Foundation for Arable Research (FAR) – a levy paid organisation – do not have a breeding programme per se but are supporting the growers and the breeders, for example, to undertake cultivar trials. FAR assesses independent performance relative to standards. They will give findings on performance rather than recommendations.

[16] https://www.plantandfood.co.nz/growingfutures/case-studies/cereal-crops-for-new-zealand-conditions/our-cultivars

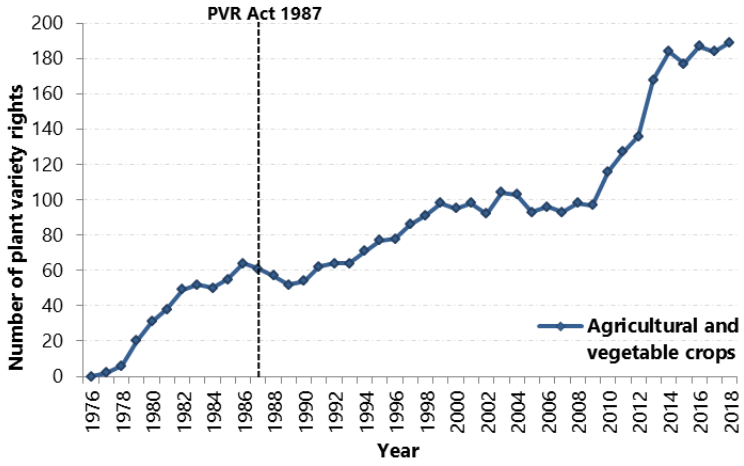
Time to market

Breeding programmes are a long-term investment—it can take at least 10 years to develop a new variety. For example, we heard from breeders that some recent products coming to market took over 15 years to develop.

Protected varieties

The agricultural and vegetable crops sector experienced a period of significant activity and increased number PVR applications in the late 1990's. This was followed by a step increase in the total number of PVRs grants by the early 2010's. As at 1 January 2019, there were 189 PVRs for agricultural and vegetable crops (equivalent to 14.6 per cent of all current PVRs).

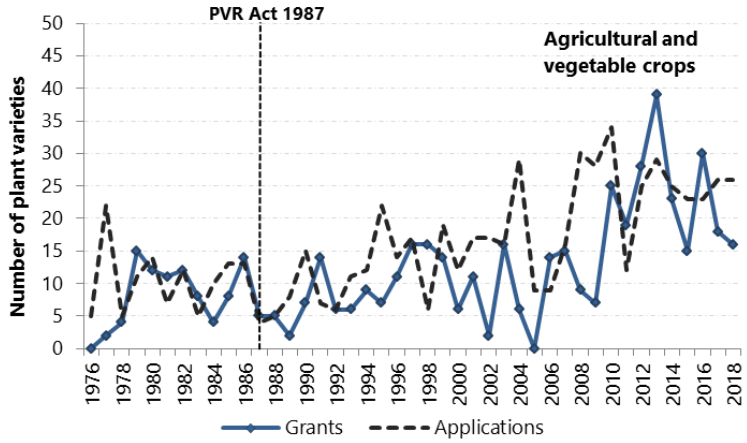
Figure 16 Total number of registered PVRs for agricultural and vegetable crops (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

The number of new applications and grants appears to still be trending upwards; this should further increase the number of protected agricultural and vegetable crop varieties in New Zealand.

Figure 17 Annual number of PVR applications and grants for agricultural and vegetable crops (1976-2018)

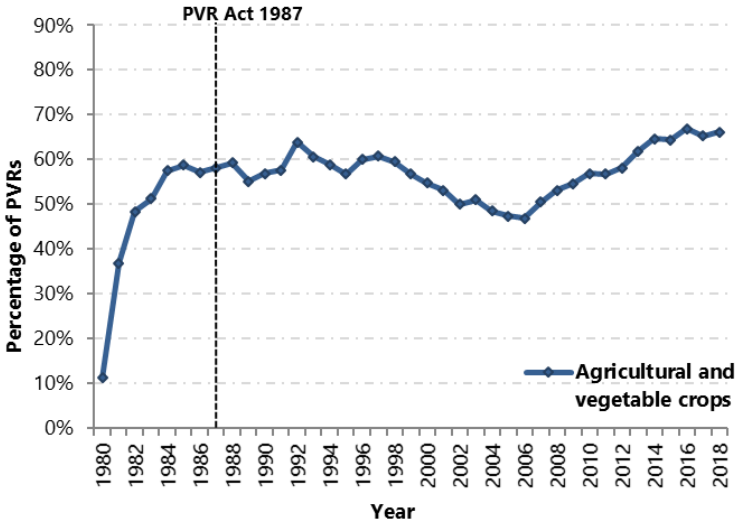


Source: Sapere Analysis, New Zealand Intellectual Property Office

	While PVRs are almost universal for commonly sold varieties of wheat and barley, breeders find it challenging to license and attract royalties for those varieties for more than a few years. **Royalties** Both end point royalties—paid when a farmer harvests and sells the crop—and seed point royalties—paid at the purchase from a supplier store—are used. End point royalties are levied for: • Grains – royalty amounts are set out alongside industry levies on purchase orders. • Wheat – ranging between $3 to 5 per tonne of licensed wheat produced. • Peas – ranging between $2.50 to $5.00 per tonne of licensed peas. • Lentils – approximately $7 per tonne of licensed lentil. Seed point royalties are levied for: • Barley/cereals – approximately $100 per tonne of licensed barley bought (however the royalty capture rate is not transparent like with other crops). • Other vegetables (carrots, potatoes etc) – unknown. When new licensed varieties are introduced, they are profitable to the firm introducing them but any additional profitability that might come from being PVR protected can be short lived. Industry representatives told us a new licensed variety can command a price above what a non-licensed variety would obtain, but only for 2-5 years. Breeders of cereal grains and agricultural crops told us that the royalties they were receiving were not sufficient to remunerate them for their entire investment in new varieties. They told us they had to 'innovate or die' in order to compete in a very competitive market. They also told us that new seed development can be a worthwhile investment when viewed holistically – even if (as one breeder noted) "royalties only cover 25 percent of our investment". This is because new seed varieties are often treated as a 'foot in the door' for selling other products like chemicals, fertilisers or future seeds. One farmer told us that the large cereal seed suppliers are profitable, but not necessarily because they rely on PVR'ed varieties. Instead, the profitability was coming from having contracts with growers (who supply cheaply) and relationships with buyers (who buy at high mark-ups). He noted that the mark-ups on grains and seeds are substantial (e.g. grown for $2.20/kg, sold for $10-12/kg).
Evolution	Research is becoming increasingly private (that is, the cereal seed companies are taking more research in-house, and the CRIs are focussing on a narrower range of research topics). There is also an increasing

international influence in the development of new varieties. Since the mid 2000's the percentage of PVRs registered to a foreign company/owner has been increasing. This could be because New Zealand growers are being used to multiply seeds for foreign companies who develop seed varieties for offshore markets. New Zealand growers are used to multiply seeds for new varieties destined for Northern hemisphere markets. This avoids the Northern hemisphere Winters and gets a new variety to market more quickly.

Figure 18 Foreign share of PVRs for agricultural and vegetable crops (1980-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

American literature on innovation in wheat and grain varieties suggested there may be a threat of 'churn' in the development of new agricultural crop varieties to meet market demand. By 'churn' we mean the addition of characteristics that are of low marginal value to consumers, that have fleeting appeal, with new varieties only staying current for a short amount of time. However, there is no strong evidence of churn occurring (yet) in New Zealand. For example:

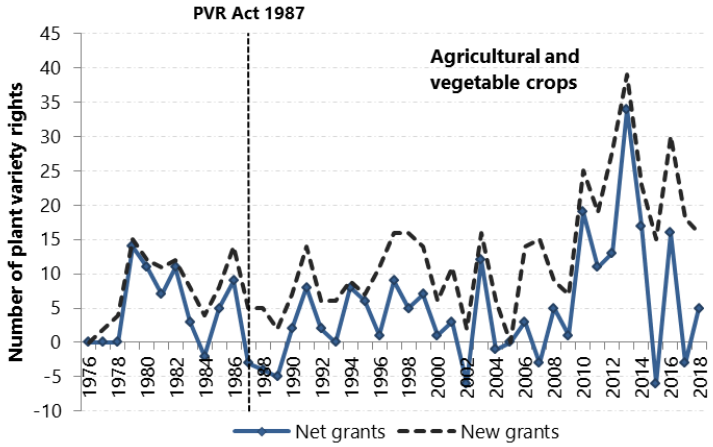
- The mean length of active PVRs dropped following an influx of new PVR grants but is beginning to increase again.
- The covariance between new grants and surrendered + expired grants is positive, suggesting a positive relationship between the two; although the strength of this relationship is weak (correlation = 0.294).

Net grants is equal to the number of new grants minus the number of surrendered + expired grants in a particular year. It measures the change in the 'stock' of protected varieties.

It will be important to monitor these two trends above. If both: (a) the covariance and correlation between new and old grants increases; and (b) the mean number of years active stabilises at this lower rate (or decreases), then further inquiry could be justified to understand the cause.

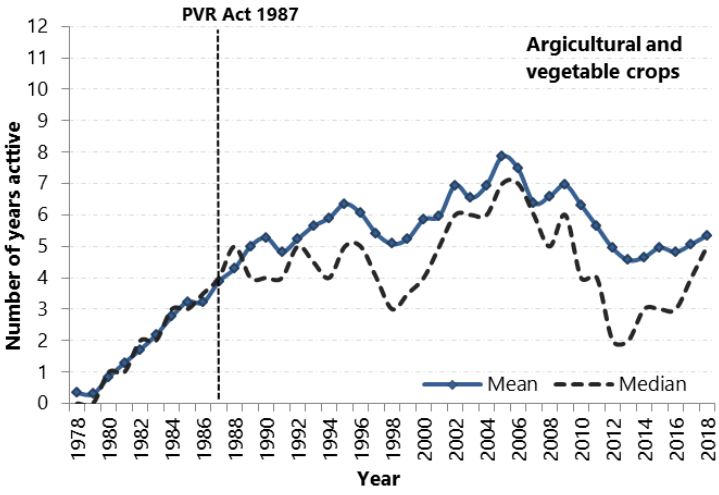
Together, (a) and (b) may be indicative of PVR 'churn' rather than innovation as intended by the regime.

Figure 19 Annual number of net grants and new grants – Agricultural and vegetable crops (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

Figure 20 PVR length – Agricultural and vegetable crops (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

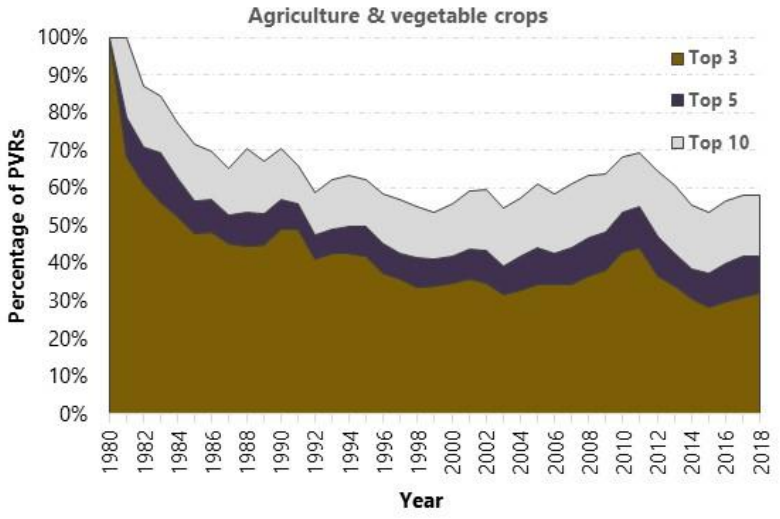
Industry structure

Current state

There are over 2,700 farmers in New Zealand involved in arable cropping activities, with combined farm gate sales of approximately NZ $1Bn, including cereal grains, pulses, maize grain and specialised seed crops for export and domestic markets. Annual crops are grown from the northernmost parts of New Zealand down to Southland, with maize being the dominant crop in the North Island whereas cereal grains (wheat, barley) and seed production (grass seeds, legume seeds and vegetable seeds) is carried out mainly in Canterbury and Southland.

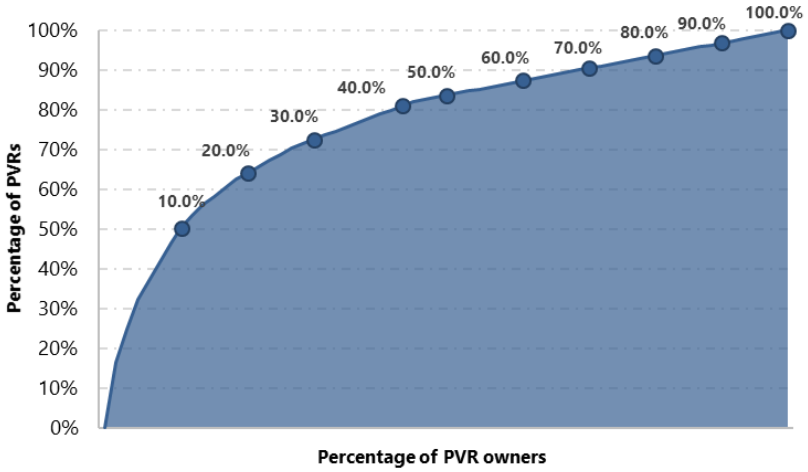
The cropping industry is very competitive, with a number of players introducing new varieties which quickly get added to the shelves of farm suppliers. The market is highly competitive and dominated by two large players, but with an active set of smaller players.

Figure 21 PVR length – Percentage of agricultural and vegetable crops PVR held by individual firms – per annum (1980-2018)



Source: Sapere analysis, New Zealand Intellectual Property Office

Figure 22 Agricultural and vegetable crops PVR concentration – as at January 1 2019



Source: Sapere analysis, New Zealand Intellectual Property Office

	The supply of cereal seeds is dominated by producers who are offshore or who have international ownership interests. As at 1 January 2019, 66 per cent of PVRs for agricultural and vegetable crops were registered by overseas firms (only Cropmark and Luisetti are majority NZ-owned). However the offshore-owned firms still have research programmes in New Zealand. We do not have evidence to suggest that royalties are going offshore or that royalties are staying in New Zealand.
Evolution	Contracts will be used more to control the supply of agricultural and vegetable seeds to and from the market. This could potentially lead to a greater degree of vertical integration between supplying farms and seed wholesalers.
Plant characteristics	
Current state	Agricultural and vegetable seeds are relatively quick to crop. While there is a market for seeds that have been multiplied on New Zealand farms (including carrot seeds), the majority of value to the New Zealand economy from this sectors is in the harvested crop (e.g barley, wheats, oats, vegetables). Several new varieties of crops have and are being introduced, and the industry has experienced large productivity gains from new varieties and new farming practices over last 20 years. For example: • in the 80s, grain farmers used to get 5-6 tonnes of wheat per hectare • in the late 90s, R&D was highly successful, and farmers increased yields to 10 tonnes of wheat per hectare • now, it is common to get yields of 13 tonnes of wheat per hectare, but gains have plateaued. Gains in the 2010s have been due to irrigation and fungal resistance, not necessarily to the variety itself.
Evolution	Agronomic performance is key – new cultivars have improved intrinsic resistance to pests and diseases, and there is an increasing focus on cultivars with efficient nutrient and water requirements. DNA marker technology. Advances in hybrid technology.
Legal and social institutions	
Current state	Grower contracts are used as the primary mechanism to ensure that breeders can appropriate returns through royalties for licensed varieties. Non-multiplication provisions in these contracts are common, where sales are conditional on the farmer not multiplying the seed. PVRs are used to protect new varieties but not always (as above, of the 20-25 varieties of commonly sown wheat, only 9 are licensed. Of the 12-15 varieties of barley, only 3 are licensed). The large increase in PVRs could be a result of New Zealand farms being used to 'multiply' varieties destined for use overseas. Generic varieties are maintained as an industry good, via a farmer levy.

Evolution	The face of the industry is changing away from 'high trust' and 'self policing', as the industry is increasingly driven by entities that are domiciled or owned outside NZ.
Characteristics of market demand	
Current state	New Zealand wheat, barley and maize was either milled for flour (wheat), or went into feed for pork, chickens or cows. Vegetable seeds are usually supplied for the NZ farmer market. The exception is carrot seeds, which is export-led. Demand is a mix between local and offshore demand (exporting to similar latitude countries). NZ growers do 'multiplication', whereby seeds are bulked up for overseas suppliers.
Evolution	Meeting consumer demands around food production. Safe food, wholesome food, ethically produced food, food produced in environmentally friendly systems and affordable food. Commerce Commission is currently assessing PGG and DLF merger – the outcome of that will affect the competitive outlook.

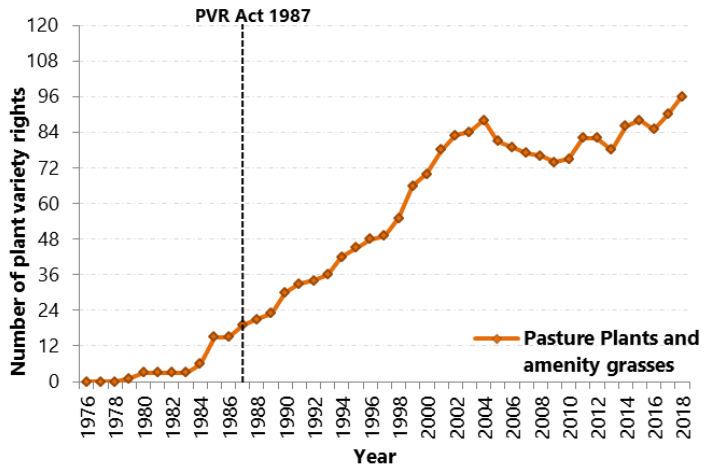
4.2 Pasture plants and amenity grasses (and fungi)

Fungi are captured here as all protected fungi species are endophytes[17]

Breeding activity and financial flows	
Current state	**Breeders and researchers** Breeding programmes for pastoral grasses are either run privately or run through industry joint ventures where the key partners are PGGW, AgResearch, Lincoln University, and Plant and Food Research. The larger private programmes are being undertaken by: DLF; Syngenta; Cropmark; Seedforce; Luisetti; Agriseeds; Pioneer Genetic Technologies; Baremburg; Germinal; and VP Maxx. Research funding is being channelled through three JV entities: • Grasslands Innovation (~$9m p/a), • Forage Innovation (~$4m p/a) and • Endophyte Innovation (~$1 m p/a). There are also programmes focussed on the maintenance of generic varieties (for example the FAR research funded in part by a Fed Farmers levy) e.g. Nui but these are not PVR-led. AgResearch or Plant and Food Research (or other private research bodies) are being contracted by market participants to undertake applied research and testing on new proprietary cultivars. There are also a number of international institutions which provide similar services to seed companies based here, such as Agriseeds and Midlands Seed. The Foundation for Arable Research (FAR) supports growers to independently observe performance of a breed. **Time to market** Breeding programmes are a long-term investment and are typical a10 – 15 year cycle to market. **Protected varieties** While the 'boom' in PVRs for pasture plants and amenity grasses appeared to end in the early 2000's, there is still a positive trend in the number of protected varieties, albeit a little volatile. As at 1 January 2019, there were 189 PVRs for pasture plants and amenity grasses (7.4% of all PVRs).

[17] The fungi registered as NZ PVRs are all endophytes, which are fungi that live on another plant (i.e. ryegrass and clover). So endophytes are commercialised via the ryegrass and clover industrial system. Looking at the PVR database, Fungi only has 4 breeders who have registered PVRs.

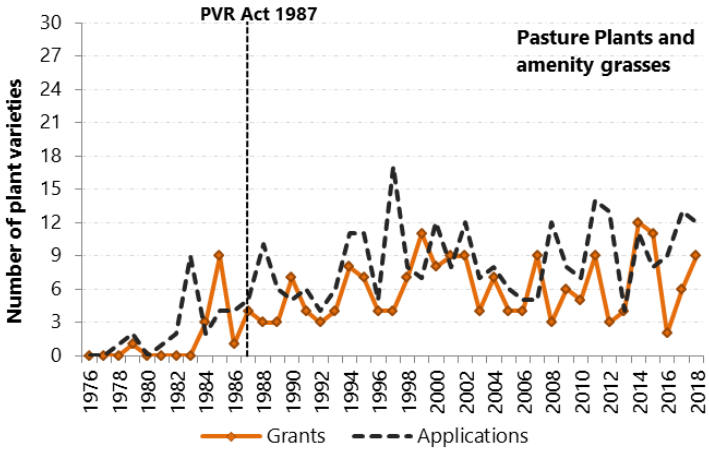
Figure 23 Total number of registered PVRs for pasture plants and amenity grasses (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

The number of new PVR applications and grants for pasture plants and amenity grasses has been reasonably stable over the past 30 years. The observed drop-off in the total number of protected varieties in the early 2000's is therefore due to PVRs being surrendered or expiring, rather than a reduction in the development of new varieties.

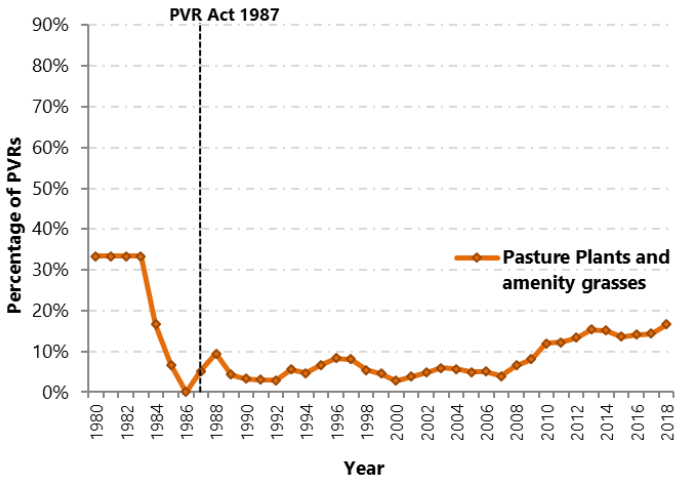
Figure 24 Annual number of PVR applications and grants for pasture plants and amenity grasses (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

Protected varieties are highly concentrated for use in local markets. This is reflected in the relatively low number of PVRs registered to foreign applicants – as at 1 January, only 16.7 per cent of the granted PVRs for pasture plants and amenity grasses were registered to international individuals/companies. We note however that this number has been slowly trending upwards over the last 10 years.

Figure 25 Foreign share of PVRs for pasture plants and amenity grasses (1980-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

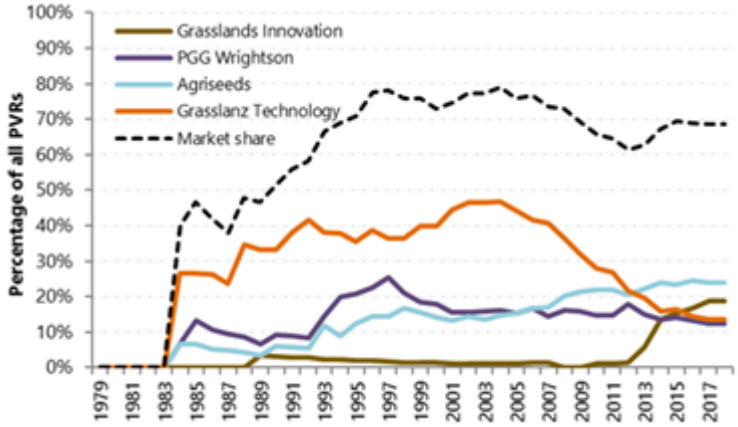
Royalties

Seed point royalty payments are set out in license agreements. A typical royalty capture rate for a protected grass or clover variety is 10 per cent of the wholesale seed price.

Evolution	Expect to see increasing market concentration, channelling commercial rewards from new varieties back to 1-2 highly dominant firms, and the research entities they have entered into joint ventures with.

Industry structure

Current state	This is an intensely competitive market, predominately developing NZ grasses for the NZ farmer market (with some sales offshore). There are large marketing budgets and intensive research and breeding programmes to develop new varieties. So, sellers have had to have something unique to participate. To illustrate, there are 57 varieties of ryegrass on the market in NZ and almost all are protected by PVRs. Historically, the three majors are: • Grasslanz; • PGG Wrightsons; and • Agriseeds. Grasslands Innovation (a joint venture between Grasslanz and PGG Wrightsons) has started to compete. Collectively, these companies have just under 70 per cent of all PVRs for pasture plants and amenity grasses.

	Figure 26 Percentage share of PVRs for pasture plants and amenity grasses (1979-2018)  **Source:** Sapere Analysis, New Zealand Intellectual Property Office
Evolution	Business models used to develop and protect value through the value chain are likely extend their sales and mature in their existing markets. This will be achieved through a combination of industry structure, IP protection and branding/marketing.
Plant characteristics	
Current state	Pasture plants and amenity grasses are easy and quick to multiply. Often partnered with patented endophyte technology.
Evolution	Expect to see further investment in endophyte development, genomics and DNA marker technology.
Legal and social institutions	
Current state	Reflecting the concentration of NZ breeders for NZ markets, this industry is concentrated into a small number of entities. The commercial arrangements are via JV contracts, with license arrangements controlling the supply/royalties for seeds.
Evolution	Increasingly PVRs are paired with contracts in attempts to try to capture the whole value chain from breeding to marketing.
Characteristics of market demand	
Current state	Demand for amenity and pasture grasses is from NZ beef and dairy farmers, with some sales to Australian farmers.
Evolution	Exports to parts of Australia may intensify. Commerce Commission is currently assessing PGG and DLF merger – the outcome of that will affect the competitive outlook.

4.3 Fruit and nuts

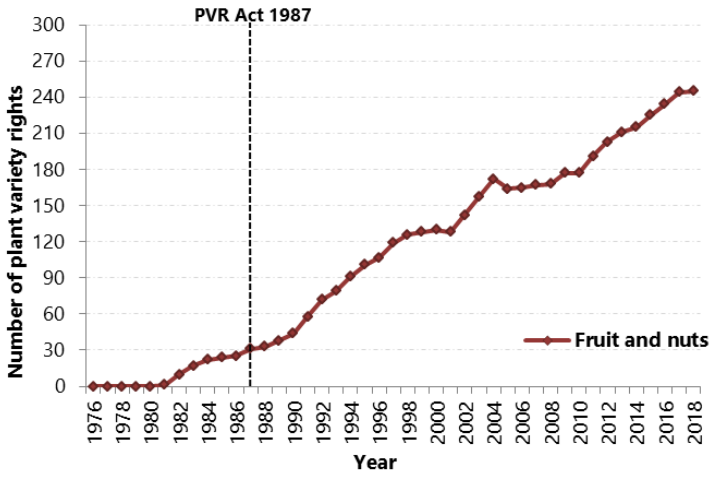
Breeding activity and financial flows

Current state	**Breeders and researchers** Fruit-related R&D investment in NZ tends to be channelled into contracts with Plant and Food research. The largest breeding programmes are PREVAR (established in 2005)[18] and the Zespri programme. There is also a Hot Climate programme[19] (established in 2002) for breeding apples and pears for hot climates. Plant and Food Research is at the centre of each of these programmes. There are smaller-scale breeding programmes (e.g. berries, pipfruit, stone fruit etc.), which are either privately operated or in collaboration with Plant and Food Research. **Time to market** Breeding programmes to develop new varieties for market are highly crop dependent. **Protected varieties** The number of fruit and nut protected varieties has continuously increased since the PVR Act was introduced into law. Over the last decade, the number of applications and grants has been trending upwards. As at 1 January 2019, there were 245 PVRs for fruit and nuts (equivalent to 19.0% of all PVRs at the time).

[18] The PREVAR programme has delivered brands such as PiqaBoo, Rockit, and Smitten to market – has been supported by investments from peak body New Zealand Apples and Pears, along with Plant & Food Research. Australian growers and the Australian government have also invested A$11m in Prevar through Apple and Pear Australia (APAL) and Hort Innovation (along with its predecessor Horticulture Australia Limited). However, from this year onwards, APAL and Hort Innovation will cease their funding. Under a new structure, APAL will retain a 16 per cent shareholding in Prevar (down from 45 per cent). APAL will continue to receive a proportion of royalties generated from any new Prevar cultivars that are commercialised globally. It will also retain the exclusive commercialisation rights to any cultivars released in Australia until 2038.

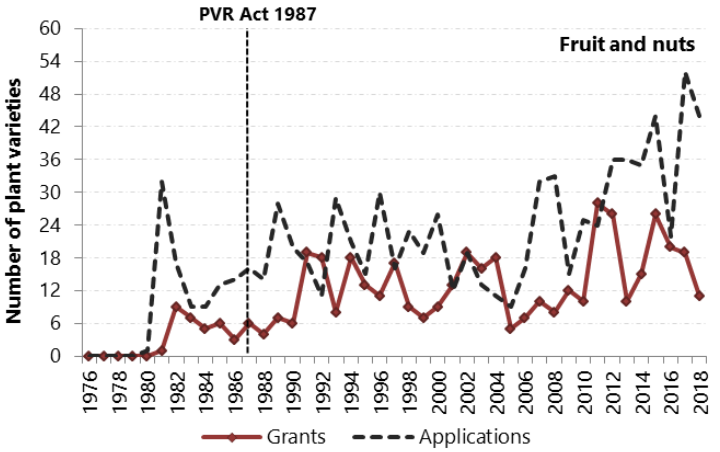
[19] The Hot Climate Programme is a joint venture between T&G Global (formerly Turners & Growers), NZ's Plant & Food Research, the Institute of Agriculture and Food Research Technology (IRTA) and Fruit Futur – the latter two both in Spain. The programme is developing new apple and pear cultivars designed to withstand sunburn, colour and firmness associated with the warming global climate. The Hot Climate Programme (HCP) was initiated in 2002 by Plant & Food Research and IRTA to address challenges faced by Spanish growers, particularly in the Catalan region, with traditional apple and pear varieties. They endure hot seasons with increased sunburn, low colour, compromised fruit textures and higher incidence of storage disorders. It was recognised that other apple and pear growing regions will begin to experience these issues as the global climate changes, and that varieties developed for these niche environments would be in increasing demand worldwide.

Figure 27 Total number of registered PVRs for fruit and nuts (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

Figure 28 Annual number of PVR applications and grants for fruit and nuts (1976-2018)

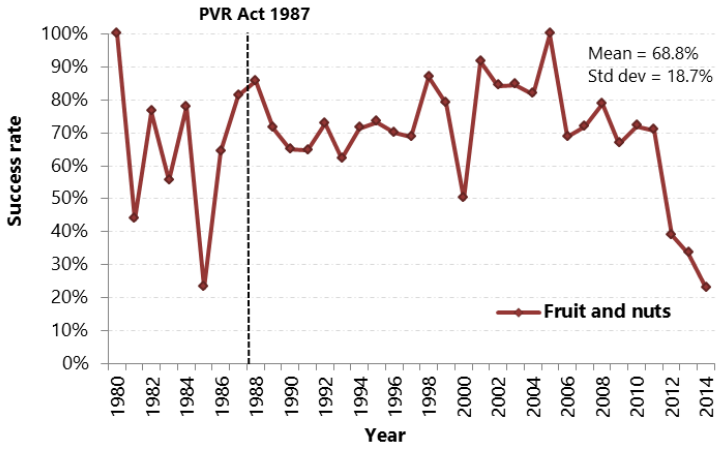


Source: Sapere Analysis, New Zealand Intellectual Property Office

The variance between the number of PVR applications and grants for fruit and nuts is increasing. This observation is reflected in a volatile, and relatively low, success rate for applications. Between 1980 and 2014, the mean success rate for applications in a particular year (i.e. applications for a PVR that were subsequently granted) is less than 70 per cent.[20] By comparison, over the same period the success rates for other industries were:

- Agricultural and vegetables – 83.7%
- Pasture plants and amenity grasses – 74.9%
- Ornamental, trees and other plants – 87.1%

Figure 29 Success rate of PVR applications made for fruit and nuts varieties made for fruit – per annum (1980-2014)



Source: Sapere Analysis, New Zealand Intellectual Property Office

Royalties

Royalty specifics are commercially sensitive, but we understand royalty arrangements are typically based on sales value or farm production (i.e. "payment for success"), as this focusses the breeder on being successful and different in the market. For protected fruit varieties, a typical royalty capture rate is 15-25% of the value of the fruit at the end of the value chain; it can be as low as 8% and as high as 33% depending on the crop and negotiating power of the breeder.

Royalties can also be captured through per hectare licenses to grow and sell the fruit. For example the licenses for growers of Zespri SunGold are auctioned (the median license price at auction was $267,000 per hectare in 2018). The price paid for a license operates as a revenue stream for Zespri, some of which is directed back into R&D (we cannot divulge what percentage). Other examples are exclusive licensing arrangements by Turners and Growers or Miro for varieties of blueberries, or licensing revenues from Jazz or apples being returned to PREVAR or Envy apples being returned to T&G.

The chief executive of Apple and Pear Australia has recently stated in a press release that any dividends generated by PREVAR will flow back into the Hort Innovation Apple and Pear Fund for re-investment in industry research and development.[21]

Evolution

The Apple industry is continuing to invest in new varieties. Out of all the 33 countries profiled in the Apple Review (2018) NZ has the highest percentage of new varieties in production.

[20] We don't consider the most recent years because of the time lag between observing an application and the subsequent outcome of that application.

[21] http://www.fruitnet.com/asiafruit/article/178358/new-structure-for-prevar

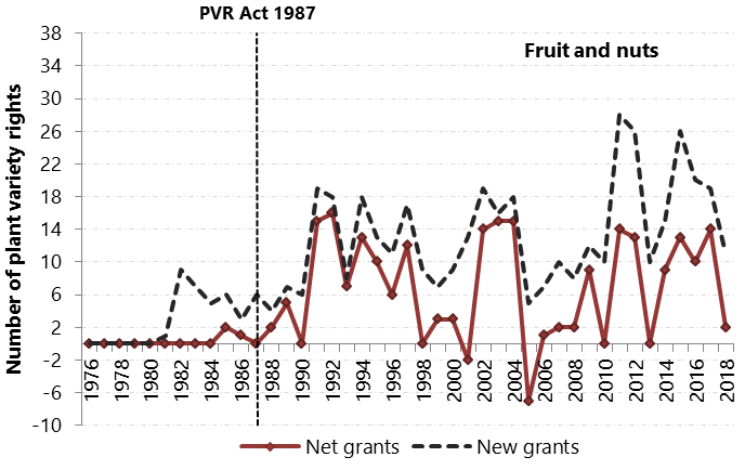
The number of independents (i.e. small scale breeders) undertaking breeding programmes is expected to shrink. The larger breeders have significant economies of scale to make significant and long term investments, making it difficult for smaller breeding programmes to compete.

Expect to see more royalties applied on harvested material in berries, pipfruit, avocados and stonefruit (e.g. the SEEKA system for Gem avocados), where they apply a royalty on the harvested fruit not just the trees. The harvested material is controlled through contract terms.

The potential concentration of competition may incentive a 'churn' effect in breeding programmes. There is no evidence of this happening yet:

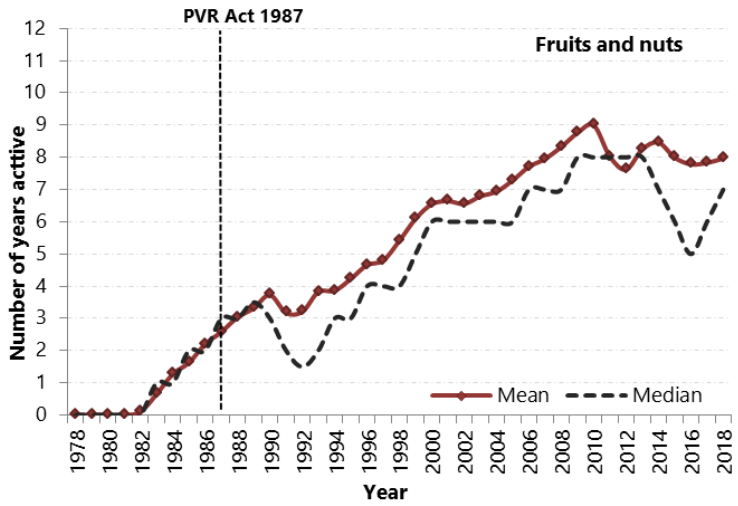
- The covariance between new grants and surrendered + expired grants is positive, suggesting a positive relationship between the two; however the strength of this relationship is somewhat weak (correlation = 0.414).
- The mean length of active PVRs has been reasonably stable over the last decade despite an increasing number of new protected varieties being registered.

Figure 30 Annual number of net grants and new grants – Fruit and nuts (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

Figure 31 Mean PVR length – Fruit and nuts (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

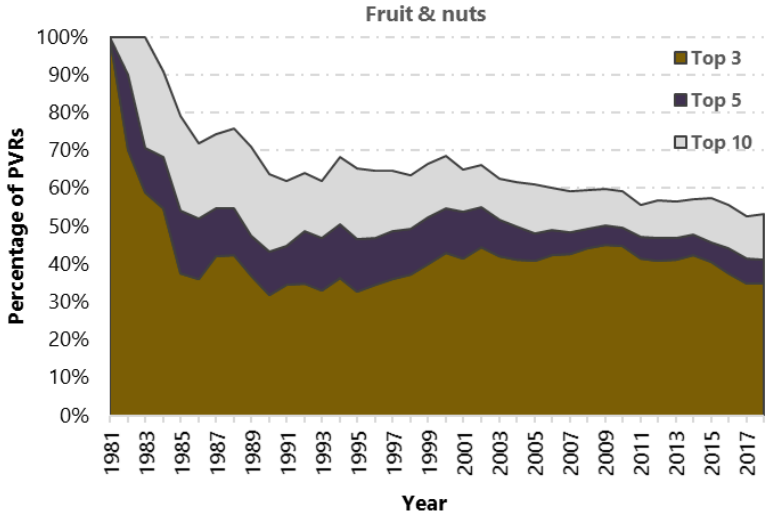
Industry structure

Current state

An intensely competitive market, driven by overseas consumer demand (through supply arrangements with supermarkets and produce brokers, wholesalers and exporters).

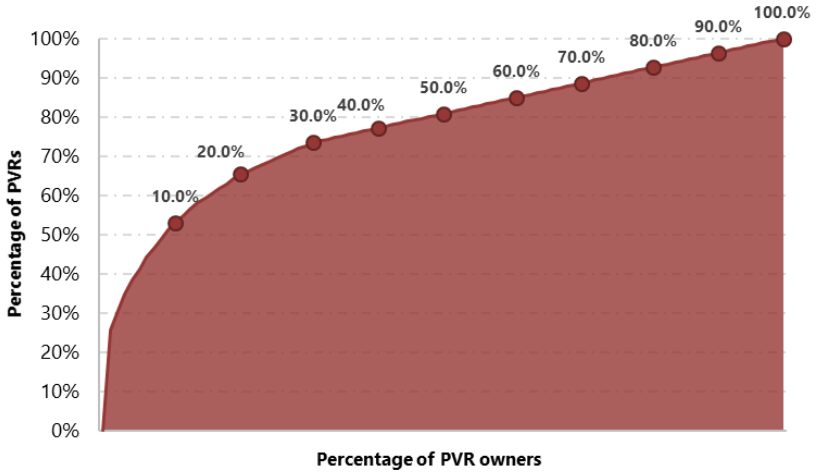
There are many PVR owners, with a small number of large of large firms.

Figure 32 Percentage of fruit and nuts PVR held by individual firms – per annuum (1981-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

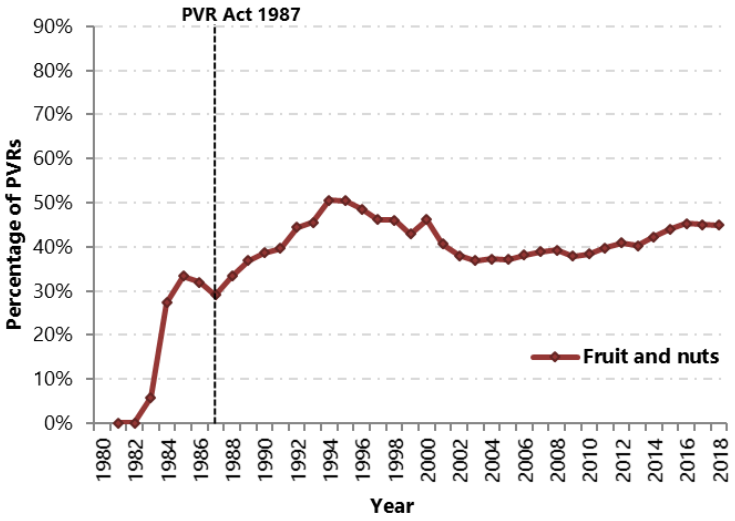
Figure 33 Fruit and nuts PVR concentration – as at January 1 2019



Source: Sapere Analysis, New Zealand Intellectual Property Office

There is significant foreign involvement in the research and development of new protected varieties. This peaked in the 90's at 50% of all PVRs, dropping to 40% in the 2000's. The percentage of PVRs for fruit and nut varieties registered to foreign applicants is increasing upwards again.

Figure 34 Foreign share of PVRs for fruit and nuts – per annum (1980-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

Evolution	Expect increased protection of value throughout the value chain for different fruit and nut varieties, such as berries and pipfruits. Investments in marketing alongside PVR to generate value.
Plant characteristics	
Current state	Very much depends on the fruit variety, hard to generalise. But typically a fruit tree is slow to fruit (berries are faster).
Evolution	Expect investment in characteristics that amplify nutrients and micronutrients, Genomics, DNA marker technology.
Legal and social institutions	

Current state	Under s17(1)(b) of the PVR Act, for vegetatively propagated fruit/veg/ornamentals, the right extends to propagation for commercial production. According to a nursery breeder, about 60 percent of new plants going in the ground are PVR protected. The economic flows are protected by PVR, master license, sub-license and non-propagation agreement (where the grower holds the license to harvest the fruit but hasn't got rights over the rootstock). So PVR is nested in amongst other arrangements. The strongest protection arrangements are observed in kiwifruit—e.g. licensed propagators typically cannot ship propagated material out to growers until they've signed all the agreements for non-propagation, royalties etc.
Evolution	Increasingly PVRs are paired with contracts in attempts to try to capture the whole value chain from breeding to marketing.
Characteristics of market demand	
Current state	Export-led, supermarket –led. By all accounts the fruit industry in NZ is booming. For example, NZ apples are the most competitive in the World. The World Apple Review (2018) ranked it first out of 33 apple producing nations. The Review highlighted that given New Zealand's relatively small size, export orientation and distance from major markets, the industry had long relied heavily on innovation to provide it with a competitive edge. The NZ apple industry has been the leader in popularising Gala and Fuji, pioneered the first true club variety JazzR, developed and produced a stream of new varieties Pacific RoseR, EnvyR, SmittenR and KoruR. Kiwifruit sales returns also continue to increase, buoyed by successes with the Zespri SunGold variety. There was a strong increase in returns for SunGold at the same time as continued growth in volumes. Sales volume for the total Gold category rose by 9 percent to 52.1 million trays and the average return per hectare across the industry was up 16 percent at $114,345. The average return per tray was $10.06 (2016/17: $8.64). These sales are supported by marketing like Zespri's 2017 'Life's Tastier When You Go for Gold' Australian marketing campaign that successfully increased awareness and trial of Zespri SunGold Kiwifruit. Similar competitive successes are being felt with pears, berries, pipfruit (albeit at a much smaller scale than apples and kiwifruit).
Evolution	There is nothing to suggest that market demand will not continue to respond to NZ's continued investment in new fruit varieties.

4.4 Ornamentals, trees and other plants

Breeding activity and financial flows

Current state

Breeders and researchers

Plant & Food Research has developed a number of commercially successful ornamental cultivars that are now widely sold worldwide including 'Bonfire' and Bonfire 'Choc Orange' begonia, Opal lilies, Novel colour gentians, including pink 'Showtime Spotlight' and red 'Showtime Diva' and Hybrid Limonium. Private breeders have developed PVRed roses, carnations, calla lillies and dahlias, which are licensed for export.

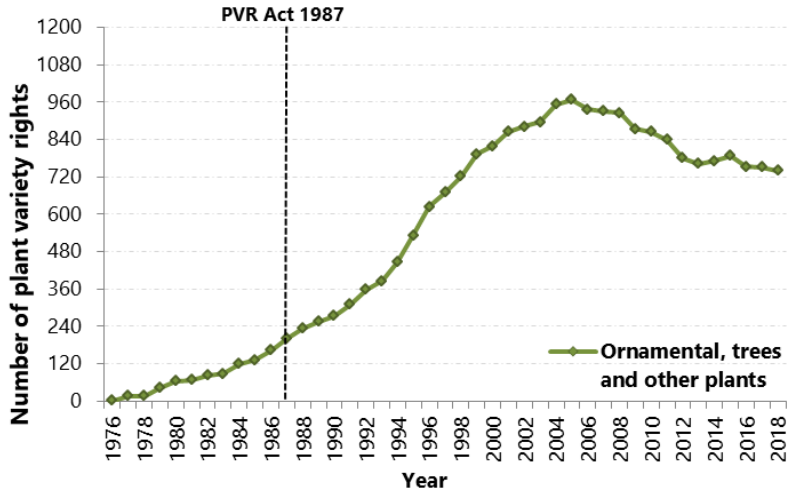
Plant & Food Research conducts research across the ornamental value chain, including breeding and propagation, plant and disease management, and production and postharvest technologies. Micro-scale breeding is done within private nurseries, often with germplasm imported from overseas.

For forestry trees, research is Levy-funded and Crown-funded research activity centring around Scion Research Institute as CRI, alongside Radiata Pine Breeding Company (RPBC), Specialty Wood Products (SWP) and New Zealand Dryland Forestry Initiative (NZDFI). However, we are not aware of any protected varieties being used at a significant scale in forestry.

Protected varieties

This is the only sector where the trend in PVR applications and grants is downward. The number of registered PVRs peaked in the early 2000's and there has been in downward trend in protected varieties since.

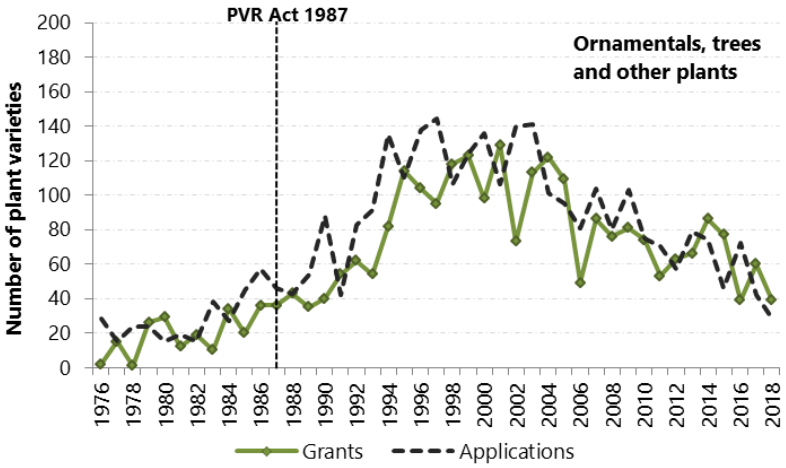
Figure 35 Total number of PVRs for ornamentals, trees and other plants (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

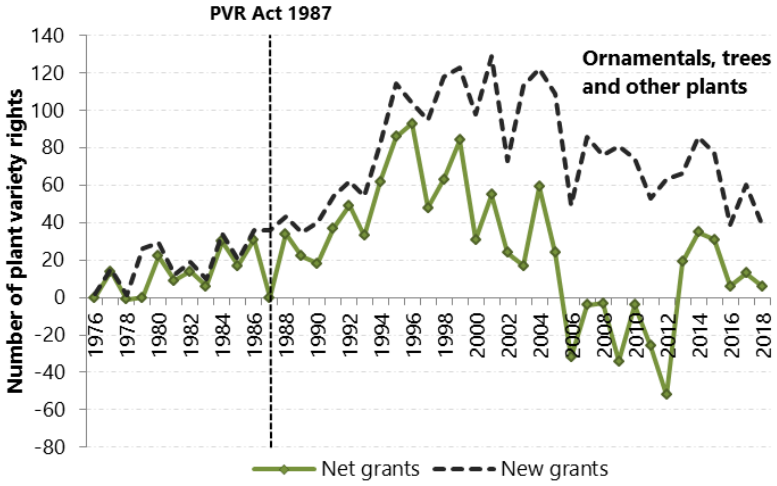
This downward trend is to be the 'new norm' as the number of applications and grants made for new varieties has been continually decreasing for nearly 20 years. Expiring PVRs is compounding the situation.

Figure 36 Annual number of PVR applications and grants for ornamentals, trees and other plants (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

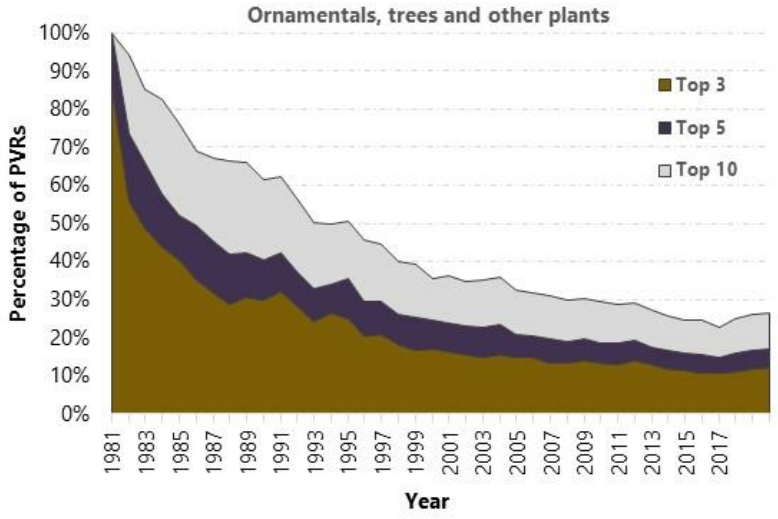
Figure 37 Net grants and new grants for ornamentals, trees and other plants (1976-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

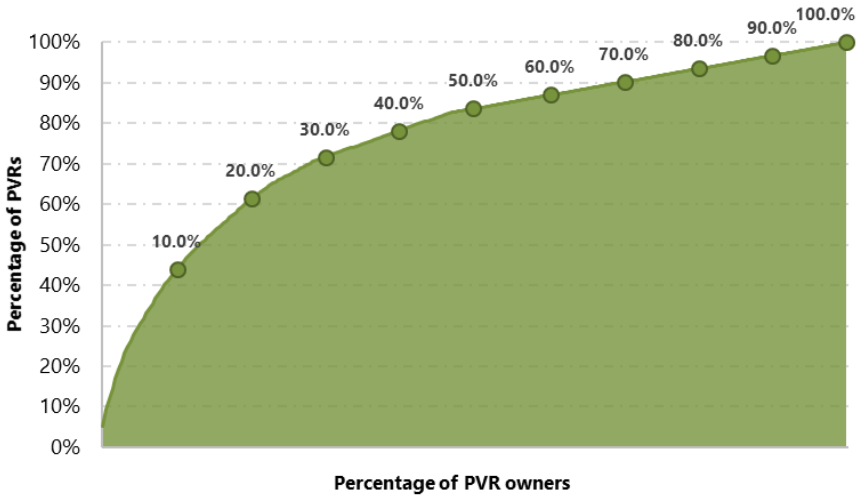
Breeder concentration is considerably less than in any other sector – for example, as at 1 January 2019 the top 5 breeders had only 17.1 per cent of PVRs in the ornamentals and trees sector, while in the pasture plants and amenity grasses sector, the comparative statistic is 75.5 per cent.

Figure 38 Percentage of ornamentals, trees and other plants PVR held by individual firms – per annuum (1980-2018)



Source: Sapere Analysis, New Zealand Intellectual Property Office

Figure 39 Ornamentals, trees and other plants PVR concentration – as 1 January 2019



Source: Sapere Analysis, New Zealand Intellectual Property Office

Royalties

For protected ornamentals, the royalties are paid through a private licensing arrangement, typically this is with an overseas breeder (if importing a breed) or buyer (if exporting a breed). Royalties are per plant or per flower propagated. For example, the royalty on a rose variety can range from 15 cents to one euro per plant ($0.25 - $1.68). In principal that royalty is paid for every rose propagated whether it succeeds for not.

For forestry trees, royalties are collected on tree sales and go to the Radiata Pine Breeding Co, but these relate to non-protected varieties (e.g. radiata pine).

Evolution	Research is becoming increasingly private, moving away from 'shared' arrangements with Plant & Food Research. Likely to see a push toward native

	varieties to respond to the Billion Trees programme and other planting programmes. Expect to see more in the manuka space, for the honey industry.
Industry structure	
Current state	For ornamentals, low profit margins due to a buyer market that is driven by big box stores (e.g. Bunnings) or large flower buyers and hugely price competitive. For forestry, demand is dominated by large forestry investment companies and there is no consumer market. Nurseries are contract-for-supply, low margin. There has been small success in export markets for roses. It is not economical for New Zealand rose growers to export their flower stems as they cannot compete with Kenyan and South American producers. On the other hand, New Zealand rose breeders have managed to conquer international markets with their new varieties. Rose-breeding nurseries in New Zealand are usually 1 to 5 hectares in size, very small compared to overseas rose farms that can extend for hundreds of hectares.
Evolution	The market for new varieties of ornamentals and trees is 'saturated', in the sense that the varieties are there. Expect to see more market emphasis on selection, i.e picking the right tree for your property.
Plant characteristics	
Current state	In ornamentals, the features that are prized are post-harvest longevity, disease resistance, fast growth and looks. In roses, some breeds aim for thornless stems. The gains that are being made in ornamental plants are of low incremental value (after big gains in the 1990s, which saw a boom in applications and grants of PVRs).
Evolution	For trees, expect future research around water requirements and eco-sourcing. More research going on in the manuka space, around which plants are most suitable for which sites. Consumer tastes drive flower breeding. Fragrant cut roses are for example highly desired by consumers. However, there is some indication that high and early expression of "real rose" fragrance is physiologically incompatible with good postharvest life. This may explain why lately some newly released fragrant cultivars are characterized by scents such as aniseed or lemon, that do not appear to be linked to poor vase-life.
Legal and social institutions	
Current state	Under s17(1)(b) of the PVR Act, for vegetatively propagated fruit/veg/ornamentals, the right extends to propagation for commercial production. For ornamentals and nurseries, the commercial arrangements are very much driven by international norms, that is, there is a private licensing contract between the breeder and the buyer of the breed and this sets out the terms of the license. A typical license allows growers to propagate and sell their flower or plant and in turn the growers agree to pay a royalty (usually, per plant propagated or flower propagated). Forestry: breeding appears to be run as a club good (for the good of the industry) but we found it difficult to find examples of protected varieties used in forestry. Low cheating in the nursery sector "reputation is very important in this industry; no-one wants to cheat the system" (Interview with nursery, 2019).

Evolution	Expect the legal arrangements for ornamentals to follow international trends.
Characteristics of market demand	
Current state	NZ-led, chain-store led. As with vegetable growing, there has been a trend for small family-owned nurseries to be replaced by a few large producer nurseries who supply large retail outlets.
Evolution	As a rule, New Zealand is a second mover in the ornamentals market, the sector is driven by international trends and tastes. The exception to this rule is New Zealand native varieties. The market characteristics for these varieties will be determined by the outcomes of the Wai262 claim and how rights over these varieties are managed subsequently.

4.5 Algae, missing out?

In New Zealand PVRs are not currently available for algae (the legislation says that any kind of plant other than algae and bacteria can have PVR protection). However, there are global and local trends that mean that policy consideration should be given to whether to include algae. Relevant factors in this consideration include:

- Algae can be cultivated, like any other plant.
- Macro algae can be proven to be distinct, uniform and stable like other forms of plants; micro algae can be harder to prove as distinct uniform and stable because they work on different breeding systems and have different lifecycles. In principle, it is possible to PVR both.
- Current international trends are pointing toward cultivation and intellectual property protection for algae as a 'value crop', giving rise to strategies for industry development that are not dissimilar to the protected fruit or vegetable varieties. In the words of one algae researcher, "there is a surge of activity around it".
- In New Zealand, the aquaculture industry is growing quickly and is focusing a lot of attention on new forms of marine-based food production and neutraceuticals. Basic research for algae is dominated by the CRI, the Cawthron Institute.
- Cultivar development would likely focus on trying to make the variety more nutrient-dense, faster growing, easier to harvest, or easier to extract nutrients from.
- Patent protection for algae-related processes, products or applications are common internationally. But in most of our western-world trading partners (such as the US, Canada and Europe) plant breeders' rights protection for algae do not exist yet.
- As an apparent exception to this rule, Australian cultivators of algae varieties can protect their innovations through PVRs. However, from an examination of the Australian register, no PVRs for algae have been granted there yet; and we can find no evidence that any applications for algae have been filed either.
- In addition to Australia, it is possible that Japan and South Korea are protecting PVRs for algae (this is an assumption based on the size of their research investment in algae, the number of algae-related patents that appear to be lodged and the size of their markets for algae products). Chinese researchers are working on algae but their property rights systems and research systems are markedly different to New Zealand's.
- Algae are typically more difficult to propagate than a standard plant (so it's going to be expensive and time consuming to generate algae lines for research and cultivar development). This provides a reason for protecting the investment in research.
- Food use and nutraceuticals (for health) is the commercial imperative behind the desire for PVR and patent protection for algae in New Zealand. The potential use of algae for pharmaceuticals is not an immediate priority for New Zealand researchers (and more likely to be via patent protection, not PVR).
- One consideration is the possible need for additional capability in the IPONZ office to assess algae-related applications. Sharing testing and evaluation resources between Australia and New Zealand might be possible.

To be consistent, we have summarised these observations into the same table format.

Breeding activity and financial flows	
Current state	There is no breeding programme but investment in basic science sits with the Cawthron Institute.
Evolution	Future investment would likely come from within the aquaculture industry or nutraceuticals. There might be pairing of algae with other plants (e.g. trees) to enhance longevity or growth of that plant.
Industry structure	
Current state	A nascent market with no current trading. No commercial suppliers of algae products. High potential for competition from Australia, Japan and South Korea.
Evolution	A new market.
Plant characteristics	
Current state	Not yet subject to much research. Algae are typically more difficult to propagate than a standard plant (so it's going to be expensive and time consuming to generate algae lines for research and cultivar development). This provides a reason for protecting the investment in research.
Evolution	Expect change. Cultivar development would likely focus on trying to make the variety more nutrient-dense, faster growing, easier to harvest, or easier to extract nutrients from.
Legal and social institutions	
Current state	None. Not currently protected by PVR legislation. Patentable.
Evolution	New Zealand could be a market-leader (Australia has provided room for algae in its PVR legislation too)., though if PVR protection for algae is not available in overseas markets, the ability to get protection in NZ may not be very useful. Protection in both Australia and New Zealand could be beneficial to both economies?
Characteristics of market demand	
Current state	No sales of algae-products at a meaningful scale. However, Japan, Korea have active consumer markets for algae products.

5. Evaluation of the innovation system

5.1 The innovation system is working well

The statistics and trends outlined in the previous section go some way toward demonstrating that the innovation system behind plant cultivation is not failing. In fact, we believe the statistics show that New Zealand's plant-based innovation is healthy. Yet, many industry representatives we spoke to raised concerns about the suitability of aspects of the PVR Act. These aspects, they say, are leading to uncertainty about how their rights will be protected if they invest in developing new cultivars. This, they state, may mean that plant-related research investment may be stifled in the future.

New Zealand does not appear to be currently missing out on new plant varieties as a result of the PVR regime. The majority of people we interviewed agreed that the PVR regime was not preventing new varieties (although we received many, many comments about the challenges associated with the import regime).[22] Looking at the statistics, the number of applications has fallen from 170-200 per year in the second half of the 1990s to 125-150 per year in the period 2012-2018 in New Zealand. This, at first glance, may appear concerning, and may indicate that New Zealand is somehow missing out. But this trend is mirrored in comparative countries that have acceded to UPOV 91 (like Canada, the United States and Europe as a whole). It possibly reflects a general, global cycle which was driven by advances in plant breeding in the 1980s and 1990s that have now tailed off. It also reflects a change in the mix of species. There are fewer varieties of ornamentals coming through (high volume, relatively low value) and more varieties of fruit and agricultural plants coming through (lower volume, relatively high value).

We have observed a relatively healthy, dynamic system for generating new cultivars from within New Zealand. From the investment behaviour we have observed, there must be a high degree of trust and confidence in New Zealand's systems for protecting plant-related IP. This suggests the PVR system is working pretty well for importers of plant material, developers of new varieties and those seeking to protect their rights. The fruit sectors are booming, off the back of sustained investment in new varieties.[23] Similarly, the pastoral grass sector has continued to invest in profitable ryegrass varieties, underpinning the hugely profitable dairy sector. The examples of new, successful varieties being introduced are too numerous to list, but the overall picture is a positive one.

We did not see evidence that importers of plant material are being dissuaded from bringing propagating material into New Zealand because of our PVR regime (although this is hard to assess quantitatively). We heard several comments that PVR registration is not a major issue for overseas licensors (but import health standards are). New Zealand appears to be keeping up with the world's

[22] In particular, the border security/bio security for germ plasm is causing real and frustration hold-ups for plant breeders. The lack of updated import health standards is slowing progress in the hops, ornamentals and fruit sectors. In addition there is very limited space in post-entry quarantine facilities, which makes import costly and slow.

[23] Hort News 20 February 2019, "Top Notch Apple Crop Expected". Pipfruit New Zealand Press Release, 23 May 2018, "NZ Apple Industry Leads the World Four Years Running" New Zealand Herald, 2 December 2018. "Zespri eyes North America for kiwifruit orchards as Sungold sales take off".

best in apples, kiwifruit, hops and in berries (for example, Plant and Food's raspberries being sold into the USA).

We have seen a combination of legal instruments being used to protect property rights in new plant varieties, including PVRs, contracts and patents. These legal instruments are being used in parallel with industry structure to strengthen the appropriability of plant innovations.

This confidence in PVR-owners' ability to protect innovations has supported a vibrant research scene. Joint venture arrangements between CRIs and private entities have emerged and are becoming more sophisticated, and these working to generate and commercialise new cultivars.

The new cultivars that are being introduced are valuable additions to the market. We looked for evidence of 'churn' but did not find obvious examples. Imports of new cultivars from offshore do not show signs of tailing off, or failing to reach New Zealand because of concerns about IP protection. We have observed confidence in the PVR office to assess and process applications, with industry participants noting that the Intellectual Property Office of New Zealand was easy to deal with and appropriately flexible to their needs.

5.2 Breeders say their trust in IP protection is eroding

This positive conclusion comes with a warning. Breeders in the industry have told us that their formerly high degree of trust and confidence in New Zealand's PVR system is starting to erode. The industry has a vested interest in securing stronger rights, so these claims need to be assessed as objectively as possible.

On the legislative side, concern was expressed about (in order of our assessment of the strength of feeling):

- being seen to be lagging the rest of the World in adopting UPOV 91;
- lack of enforcement powers;
- inability to extend enforcement to unauthorised harvested material (in particular, from offshore);
- the uncertainty created by compulsory licensing;
- the evaluation settings, and the need to keep up with advances in the technology; and
- royalty capture for farm saved seed.

It goes beyond the scope of this paper to provide a detailed analysis of each of these issues. But suffice to say many representatives of breeders and firms that rely on cultivated plant varieties see the system as fraying at the seams and are supportive of moves to modernise it. This was evidenced in the submissions, which emphasised the need for change.

New Zealand's plant-based producers operate in a difficult environment. To be successful they need scale. Scale is difficult to achieve from a small, distant economy. To create scale they must invest in a defendable value proposition (a better plant, a better brand, a better path to market). But the investment they need to create this value proposition is large, risky and takes time to come to fruition. Because of this, investors in plant-based research need to have a high degree of certainty that any investment they make in a new cultivar will be protected and 'highly appropriable'.

6. Information for policy questions

In previous chapters we have established a picture of the innovation systems behind the development of new cultivars in different crop varieties, aggregated into broad sectors. This description of innovation systems is useful because it can help to understand what might happen if PVR settings are changed. We have also highlighted the role that industry structure and plant characteristics play, alongside legal settings, in determining industry outcomes.

In the next chapter we provide information that may help MBIE evaluate three policy decisions:

1. Whether or not to extend PVRs to cover farm-saved seed.
2. Whether or not to extend PVRs to cover harvested material (as opposed to just propagating material).
3. Whether or not to amend the settings associated with compulsory license applications.

7. Information relevant to policy on farm-saved seed

Farm-saved seed (FSS) is seed from a grower's own harvested crop which is used, by the same grower, to sow next season's crop. By using farm-saved seed, growers do not need to purchase new seed to meet their sowing requirements each year. But saved seeds often deteriorate in quality when re-sown. So a crop farmer faces a trade-off when deciding to save seeds: should he incur the higher cost of more frequently purchased seed or incur the deteriorating performance of progeny seed.

FSS is a common business practice in the agricultural and vegetable crop sector and the pasture plants and amenity grasses sector. So these sectors have an interest in how the PVR Act may change following the review.[24] The fruit and nut sectors, ornamentals are not affected by the provisions.

The current version of the PVR Act provides that PVR owner's permission must be obtained before:

(a) selling, or offering to sale, propagating material of the protected variety;
(b) producing propagating material of the protected variety for sale as propagating material.[25]

Since seed of a protected variety that is saved by a grower to sow next season's crop is not: (i) *produced for sale*; (ii) *offered for sale,* or (iii) *sold*, growers are not required to seek the PVR owner's permission to save seed under the PVR Act. The Act is silent about royalties (that is, a PVR owner can seek royalties for saved seeds by contract).

New Zealand is a party to The Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which is a free trade agreement involving New Zealand and 10 other countries in the Asia Pacific region. Our CPTPP obligations require New Zealand, at a minimum, to align our PVR legislation with UPOV 91. So adhering to UPOV 91 requires legislative change. One of these changes is to the PVR rights over saved seed.

Under the PVR Act, using FSS to sow next season's crop is not in conflict with the rights afford to PVR. Whereas UPOV 91 requires that PVR owners must give their permission for the following activities in respect of propagating material of protected varieties:

(a) reproduction of the protected variety;
(b) conditioning for purposes of reproduction; and
(c) stocking of propagating material for any of the above purposes.

That is, the expanded exclusive rights required by UPOV 91 mean that, in the absence of any explicit exception, PVR owner's permission would be required to use saved seed.

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[24] Farm Saved Seed is limited to self-fertilizing and vegetatively-propagated crop species due to the manner of biological reproduction. The development of hybridization for certain species starting in the 1920s and 1930s provided a technological means to encourage farmers to purchase new seed for each cropping season, since progeny seed saved from such varieties performs relatively poorly and inconsistently.
[25] Distinct from FSS, there is a breeders' exemption (section 18 of the PVR Act) which means breeders can use seeds for research without having to obtain permission.

However, UPOV 91 also has a specific exception that allows member states to permit farmers to use saved seed "within reasonable limits and subject to safeguarding of the legitimate interests of the breeder".[26]

Therefore, policy makers still have some flexibility on the subject of FSS and can decide:

- whether or not farmers can use saved seed; and
- if they are permitted, the conditions under which they can use it, subject to Article 15(2)

So, a revised PVR Act that aligned with UPOV 91 could in theory completely remove the rights of growers to retain seed. In that instance growers would be required to seek permission to use harvested seed for any future crops. All else being equal, this option would increase returns to PVR owners. However, given that this option would increase costs to growers using protected varieties, it is plausible that it will result in a lower rate of uptake of new varieties (and therefore potentially decrease returns to PVR owners). Enforcement may also be difficult and result in increased non-compliance. There may be frustration and costs involved for both PVR owners and growers if permission had to be sought in every instance.

The economics literature recognises that allowing FSS can have a net economic benefit. Saving seeds generates a benefit for the farmer (who gets increased control over his subsequent crop and a low-cost seed source). The literature also highlights the fact that enforcement of rules that stop farmers from using saved seed entirely is neither perfect nor costless, and the innovator is generally required to expend resources to identify and pursue legal action against potential infringers. So it is efficient to 'allow' a degree of seed-saving.

7.1 International context

Nearly all UPOV 91 Parties have used the flexibility UPOV 91 provides to limit PVR owners' rights over farm-saved seed to some degree. For example:

- Both Australia and Canada currently allow growers to condition and stock seed of a protected variety to sow another season's crop, without making a payment to the PVR owner.[27]However, they are not allowed to sell the saved seed to others to grow (and this would also be an infringement under the current PVR Act in New Zealand). The Australian regime allows an opportunity to have specific taxa excluded from the FSS exemption.
- The European system allows growers[28] to use saved seed of specified species only without the PVR owner's permission. For species other than the specified species, the PVR owner retains the right over farm-saved seed. Growers must also pay 'equitable remuneration' to the PVR, which must be 'sensibly lower' than the price charged for purchased seed.

[26] Article 15(2), UPOV 91

[27] At the time of writing this report, Canada is consulting on whether to implement royalties for farm-saved seed.

[28] Except for 'small' growers whom may use farm-saved seed freely and are not required to pay any fee.

Review of enforcement of Plant Breeder's Rights in Australia – Farmer's privilege and balance of rights

Responding to concerns raised about difficulties in enforcing plant breeders' rights, the Australian Government commissioned a review of enforcement of Plant Breeder's Rights[29] (PBR) in 2007. A particular issue of interest was the operation of 'farmer's privilege' or the 'farm saved seed' exception to the exclusive rights provided by a PVR.

In the review, it was acknowledged that while UPOV members are not required to provide the FSS exception, one of its aims was to achieve a balance between incentivising development of new crops and recognising that saving seed to sow for next season crops is traditional farming practice.

The existing legislation allowed PBR owners, who believed that the FSS provisions prevented them from obtaining a sufficient return on investment, to apply to have the exception removed for specific taxa (in other words a presumed right on farmers to save seeds). However, to date none had done so.

The review made three recommendations to the legislation for farm-saved seed:[30]

- There to be no change to the operation of the farm-saved seed exception, with some amendments in wording to state the provisions in easily understood terms.
- Raise awareness of the opportunity to have specific taxa excluded from the exception as part of IP Australia's education and awareness programmes.
- Encourage PBR owners to make clear to growers the conditions of sale of propagating material and their obligations in relation to future generations of it.

7.2 Industry practices

Contractual arrangements between seed supplier and farmer are becoming more prominent in the supply of agricultural and vegetable seed, and pasture and amenity grasses. Common contract terms provide for royalties and non-multiplication conditions which permit farmers to save seeds for own use but never multiply them for sale (that is, by providing permission to save seeds in contract, industry practices mirror the 'permission' condition in UPOV 91).

The industry says allowing unfettered FSS makes it difficult for breeders to know exactly who is using their protected variety and in what quantity in any one year. They like the UPOV 91 default requirement for prior permission before a farmer can save seeds. This is because unless a breeder has the ability to survey the use of FSS (and by extension, the ability to assess the degree of 'cheating'):

[29] All but equivalent to Plant Variety Rights (except for the name).

[30] Australia Government Advisory Council on Intellectual Property – A review of enforcement of Plant Breeder's Rights (2010). Source: https://www.ipaustralia.gov.au/sites/default/files/acip_final_report_review_of_enforcement_of_pbr_archived.pdf

- Licensors cannot accurately calculate how much royalty to expect from FSS.
- It is much harder to detect crops grown or multiplied without permission and focus compliance efforts.
- Farmers may still under report their use of saved seed – or participate in illegitimate trading of PVR-protected seed.

Yet, requiring permission in every instance of FSS is not the only option for helping breeders survey the use of FSS and to assess who is 'cheating' on royalties. For example, royalties can (and are) collected 'up-front' at point of seed sale when there is a likelihood that the farmer in that industry will save and re-use seeds (or, a farmer can lower the royalties they pay if he can contract that he won't save seeds).

Further, the incentives for surveying 'cheating' are changing. Now that expectations that royalties will be collected on FSS are becoming embedded, the incentives for firms to police practices on farms might change (as long as the penalties for a breach of rights are strong). For example, there might be an incentive for specialist royalty agents to establish in some industries where 'cheating' might occur. These agents would specialise in detecting breaches or collecting royalties.

Genetic testing and advances in the technology for the identification of genetic markers mean that it is becoming easier to trace and monitor 'cheating'. So, black market selling of counterfeit seeds is going to become more difficult in the future. Capturing royalties is going to be easier in the future. So, the justification for always requiring permission from the breeder for FSS is less pronounced than it used to be.

Recently in Australia a system of farmer-to-farmer licensing (or seed sharing) has been established for a limited range of varieties. In this model, the seller is licensed to sell or trade harvested seed over the fence, provided they complete a Seed Sharing Agreement with the purchaser and return it to the PBR owner. The agreement then allows the owner to establish the relevant commercial arrangements with the purchaser. This system does not seem to be used in New Zealand (but we have not tested this conclusion widely).

7.3 Submissions on FSS

Farmers of crops maintain that the ability to save seeds is helpful to them. They are generally opposed to any restrictions on their ability to use FSS, which they consider gives them confidence in supply. In the case of wheat and barley seeds, for example, some growers complained of not always being able to obtain the right variety at short notice from supplies like Farmlands or PGGW. They consider any change to the PVR Act requiring them to seek permission from the PVR owner might involve high compliance costs and complexities (even though many are already growing under contracts which provide such 'permission'). Some growers are open to the possibility of a royalty regime for farm-saved seed, so long as they remain free to save seed of a protected variety without having to obtain prior permission every time they want to sow saved seeds.

Breeders of crop seeds and pasture and amenity grass seeds consider that farmers should, in principle, pay for farm-saved seed derived from protected varieties if there was a practicable and flexible means of capturing this royalty. But they are pragmatic. The submissions from breeders did not support a strict legislative requirement for prior permission from breeders before saved seeds could be used. Instead, they considered that there should be room in the legislation to allow for terms of trade to

impose requirements or to "contract out" of allowing saved seed altogether. Contracting-out is already used in some sectors to control the practice of FSS. In other instances, terms in the contract of seed supply might have requirements to disclose the use of licensed farm saved seed (and perhaps requirements to pay royalties if that use is of a sufficiently large-scale).

When queried about the practice of FSS in interviews, representatives of wheat and barley breeders conceded that while they did not wish to see any widening of the FSS exception, the current scope of it was broadly appropriate (that is, to allow for small-scale use but not sale). The main areas lobbied for change were a strengthening of enforcement provisions for black-market selling of licensed seeds, and flexibility to capture royalties on FSS via contract.

Some wanted compulsory payment of royalties for FSS. Because growers aren't required to pay when they sow seeds that they've saved, breeders of agricultural seeds estimate that they are missing out on approximately NZD$2 million in annual royalties.[31] This set of breeders is the same set that asserts that revenues from protected varieties are not sufficient to make an adequate return on their investment in breeding new varieties.[32]

7.4 Saving seeds does not seem to be much of a problem in the cropping industry

If the practice of saving seeds was causing significant problems in the innovation system one might expect to see evidence of local breeders developing fewer new varieties and reluctance in foreign plant breeders to allow their new varieties to be imported and grown in New Zealand. We might also expect to see farmers incurring very high or inequitable costs in obtaining seeds, or problems with supply.

We have found that in practice, neither scenario appeared to be happening. Applications for PVR for new varieties of agricultural and vegetable crops and pasture plants and amenity grasses have consistently grown, and the royalties received and returned into R&D have been sufficient for large-scale breeding and testing programs to be maintained in multiple locations. International interest in New Zealand as a breeding destination has been demonstrated by new entrants like DLF entering and remaining in the market (using acquisition to acquire more rights over licensed products and breeding activities). Both growers and breeders are aware of 'cheating' and black market selling but the instances of this are "relatively rare" (interviews with breeders, March 2019). Such instances are typically resolved through letters rather than via the Courts. Nevertheless, both wish to strengthen the formal enforcement regime to allow for stronger consequences for cheating the PVR system.

[31] PBRA submission.
[32] Interviews with plant breeders, March 2019.

7.5 But FSS might be an issue for other industries, like potatoes

While the practice of saving seeds is tolerated and acceptable in the agricultural cropping industries, it is less tolerated by breeders of vegetable seeds. For example, seed potatoes. In the seed potato industry there is a six-year bulk up period from tissue cultures through to commercial seed sale. The sale in the final year of commercial seed represents six years of investment. In that industry progeny potatoes can be sowed again by the farmer, for a time.[33] So, in that industry allowing farmers to save seeds without disclosing it or paying royalties could have consequences for investment in the development of new varieties. Supply of new varieties by breeders might be under-cut by growers saving their own seed and using the progeny potatoes on their farms at a commercial scale. One breeder noted that when they looked at the impact of allowing potato farmers to save and use their own seeds, they estimated they would "only recoup about 5-7 per cent of their investment in a new variety. The surety of likely sale of the final seed generation is vital to commercial viability." So, potato breeders were keen to remove the ability of farmers to save seeds altogether.

Wheat or barley seeds are quick to seed. Compared to potatoes and other vegetables, there is a shorter wait between having the original seed, and the ability to bulk up to sell and use the progeny from that seed. So, a wheat or barley seed breeder's investment profile is different, with quicker expectations of returns. Yet while they are easy to replicate, they quickly lose value when reproduced again and again. This means that the problem is less that a farmer is using the seeds, and more that there might be black market selling beyond the farm gate. Quality control is also an issue for branded varieties that can be quickly replicated; a variety may be passed off as a licensed variety in the black market.

Generally, the ability to restrict farmers from using progeny seeds on their own farms is more useful to breeders when:

- the characteristics of the crop means it can be replicated, bulked up and replicated again without losing its valuable characteristics;
- there is a long bulk-up period (that is, the duration between someone receiving the seed and being able to use a progeny seed from it). This is because of the sunk costs associated with investing in developing a commercial line from a new breed, which requires building up sufficient volume to justify a commercial supply;
- there is a low ability to monitor whether a farmer is 'cheating' and selling the seed to others to use; and
- there is a low ability to control cheating when it happens, say, because the seed is easy to replicate or distribute, and there are so many possible cheaters that the PVR owner cannot enforce them.

[33] When one replicates tuber potatoes over multiple generations, vigour drops and disease potential increases. Growers are likely to keep some back for finishing paddocks if not enough seed has been purchased, but would probably not rely on it for main crop due to disease risks and reduced vigour.

8. Information relevant to policy on harvested material

The concept of 'harvested material' is not currently considered in the PVR Act.[34] MBIE define harvested material in its 2018 Issue Paper to include "entire plants and parts of plants, which have been grown and harvested, and:

a) are not normally used for propagating the variety; or
b) could be used for propagating the variety but is used for some other purpose (such as human or animal consumption)" (p. 31).

PVR owners currently have very limited rights over the 'harvested material' (as defined above) of their protected varieties. Under the Act, these rights arise only when:

- harvested material of a variety protected in New Zealand is imported into New Zealand; and
- the country from which the produce is imported is not a UPOV member, or, if it is a UPOV member, does not grant PVRs over the variety concerned.

More extensive rights to control the use of harvested material therefore, must be negotiated and established through contractual arrangements. Such as, requiring harvested material produced from the protected variety to be sold back to the PVR holder or another nominated person.

Rights over harvested material are considered valuable to plant breeders and PVR owners because they make the task of protecting their rights easier – if they detect instances where others are illegally using their protected variety, they have rights to confiscate the harvested material or require payment for it. Without such rights, enforcement is more difficult – the PVR owner has an onus to assert their rights and allow a reasonable opportunity for the suspected illegal user to dispute the claim that they are breaching the PVR.

UPOV 91 requires PVR owners to be given rights over any harvested material—even if the harvested material of the protected variety is not also propagating material—if:

- it was obtained through unauthorised use of the propagating material of a protected variety; and
- the PVR owner did not have a "reasonable opportunity" to assert their rights in relation to the propagating material.

Because the PVR Act does not currently include such provisions, there is a risk of the potential 'black market' use of harvested material through unauthorised propagation (i.e. if unauthorised propagation can go undetected, the harvested material or derived products can be used legitimately without any compensation or breach of PVR rights). Most breeders consider this to be a significant gap in the current legislation and consider aligning the PVR Act with UPOV 91 requirements to be the minimum necessary condition for preventing potential misuse of harvested material.

[34] Harvested material is referred to as 'produce' in the PVR Act but 'produce' is not defined.

As a party to CPTPP, New Zealand is required to align with the default UPOV 91 requirements. However, these can be made more extensive. For example, PVR owners could be given mandatory, exclusive control over harvested material without any requirements to show that they did not have a reasonable opportunity to assert rights. As another example, the burden of proof could be shifted to the defendant to disprove that there was an infringement by showing with sufficient evidence the falsity or invalidity of the allegation.

8.1 Potential costs and benefits

One benefit of making the rights to harvested material more extensive than the default is easier enforcement, particularly when harvested material is sold (as the product can be intercepted immediately, instead of waiting for 'reasonable opportunity').

One potential cost of making the rights to harvested material more extensive than the default in UPOV 91 is the potential that PVR owners end up with excessive market power in New Zealand. That is, the control over what happens to fruit (and budwood) becomes too centred on PVR owners (and the large entities that own them), driving up prices to New Zealand consumers. It would also shift the costs of defending ownership away from the beneficiaries of the PVR and onto fruit/vegetable suppliers and consumers. Thus tipping the balance between rewards for the breeder and rewards for society more toward the breeder (in the first chapter we described PVRs as attempting to strike a balance between providing an opportunity for a plant breeder to obtain a reward for their effort in developing a new plant variety, and the benefits to growers and society from having access to new and improved plant varieties).

8.2 Submissions on harvested material

Enforcement was cited as a key concern by a number of parties we interviewed as part of the research. At present, the enforcement settings in the PVR Act have been identified as being a problem area, and the Ministry of Business, Innovation and Employment has sought comment on how they could be strengthened.[35] At present, the onus is currently on PVR owners to monitor and detect potential unauthorised use of propagating or harvested material and then show that they have asserted their rights in relation to that material. Typically, enforcement is done 'off line', with parties whose rights have been infringed issuing letters or requests to desist. Enforcement can require legal support in multiple countries, under multiple sets of enforcement rules. Only two infringement cases have made it to Court in New Zealand.[36]

Given the nature of harvested material (being material that can quickly be disposed of / decompose etc), the time and costs associated with enforcement is a real impediment to effective enforcement. People we interviewed told us that introducing a clear and quick enforcement regime, as part of the changes to the Act, would give greater comfort to those looking to invest in plant varieties as well as potentially deter those who may look to use the harvested material to illegally propagate.

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[35] MBIE PVR Issues Paper, 2018.

[36] *Winchester International Ltd v Cropmark Seeds Ltd*[36] and *Cropmark v Southern Grain and Seed.*

We heard from breeders that enforcement carries material cost and complexity, and these efforts only have moderate success in obtaining compensatory payment. They made the case that extending the right to control more uses of harvested material would make expectations of royalties clearer for the different types of uses for budwood. They suggested that extending the control over uses of harvested material would provide better enforcement capability, which would deter misuse of propagating material of protected varieties without PVR owners' permission.

We also heard in our interviews that the PVR Act should work alongside contract law. The PVR Act should only provide protection for situations where the enforcement of PVR rights cannot adequately be supplemented with contractual rights (i.e. when harvested material is imported or harvested material has been produced through unauthorised propagation). In the submissions to MBIE's Issues Paper, several breeders expressed a desire to maintain the flexibility of being able to use contracts, rather than having the PVR Act determine control over and use of harvested material.

8.3 International context

We could not find evidence that other countries were protecting harvested material beyond the default arrangements provided in UPOV 91. Although UPOV 91 allows members to determine whether to provide PVR owners with more extensive rights, no member state currently gives plant breeders rights over the harvested material of their protected varieties that are additional to the basic rights required under the convention.

Case Study – Australian Government Plant Breeder's Rights Act 1994

It was recommended, following the review of enforcement of Plant Breeder's Rights in Australia, that

- The PBR Act be amended to clarify that harvested material that is also propagating material is to be considered as propagating material for the purposes of s.11, even if it is not being used for that purpose.

Section 14(1) of the Plant Breeder's Rights Act 1994 extends PBR rights to harvested material in certain conditions:[37]

> If:
>
> (a) propagating material of a plant variety covered by PBR is produced or reproduced without the authorisation of the grantee; and
> (b) the grantee does not have a reasonable opportunity to exercise the grantee's right in relation to the propagating material; and
> (c) material is harvested from the propagating material;

Section 11 operates as if the harvested material were propagating material

[37] https://www.legislation.gov.au/Details/C2018C00361

9. Information relevant to policy on compulsory licensing settings

Compulsory licensing is a requirement on the PVR holder to make the propagating material available to the holder of the compulsory license (licensee). Compulsory licensing is justified because without compulsory licensing, some breeders may 'hoard' rights or fail to put their invention to use in the marketplace. A compulsory licence can be granted if the PVR has not made reasonable quantities of the protected variety's propagating material available to the public at a reasonable price within three years (section 21 of PVR Act). Once granted, a compulsory license permits its holder to produce for sale and to sell reproductive material of the protected variety within the terms of the licence set by the Commissioner.

A compulsory license terms set out the limits on reproducing and/or selling the protected variety. When a compulsory license is granted, the PVR owner still retains the PVR and the right to exclude others from exploiting the protected variety without the PVR owner's permission. The compulsory licensee does not acquire any exclusive rights in the variety. The terms of a compulsory license can be quite specific. For example, a compulsory sale order may be applied where a person wishes to grow that variety but not produce reproductive material for sale or not produce and sell harvested material.

Compulsory licenses highlight the implicit contract between PVR and society. As described in earlier chapters, the 'contract' is that the PVR owner gets protection for a property right while society gets the benefits of new plant varieties (relative to a situation where the right is not provided with protection).

UPOV 78 and UPOV 91 both permit compulsory licensing to restrict PVR rights for 'reasons of public interest'. However, neither defines 'public interest'—this is to be determined by the member country (while balancing the requirement to ensure all measures necessary are taken to guarantee that the breeder receives equitable remuneration).

9.1 What is the public interest?

The current PVR Act implies that the State believes that the public is interested in ensuring that the variety is available to the public (i.e. the consumer) in "reasonable quantities" and at "reasonable prices". So while the State has agreed to provide some market power to the PVR owner, the State also requires that the market power must not be exploited in the sense that the PVR owner withholds the variety from the public (i.e. the consumer) or charges too much for the variety.[38]

The PVR Act places the onus on the Commissioner to decide what terms are best to protect the public interest, so there is a discretion to decide what the public interest is. The trade-offs that the Commissioner must make to determine what is in the public interest critically depend on the

[38] A PVR provides market power, and the Commerce Act accepts this market power. For example under s36(3) of the Commerce Act, actions to enforce a statutory intellectual property right such as a PVR are not considered to be taking advantage of market power.

configuration of the industry, the competitive context internationally and the expected returns from that particular variety for the parties concerned. There is high potential for these decisions to be contentious, given the size of the industries at stake. Policy makers are considering whether to provide more guidance around what a compulsory license can, and cannot, allow for.

The public interest might be considered to be wider than having the variety available at reasonable prices and quantities. For example, food security, biosecurity or low consumer prices for healthy foods might all be considered to be 'in the public interest'. The public may be considered to have an interest in ensuring that a PVR owner does not discriminate against particular individuals or competitors, or does not frustrate the development of a particular breed just 'because'.

Or, the public interest might be considered to be narrower; for example it might just be an interest in the innovation that the IP right incentivises. For example, the compulsory licensing provisions might just focus on the availability of propagating material in the domestic market and as such, the provisions might state that the export of propagating material should never be allowed in a compulsory license. A narrow focus on innovation recognises that compulsory licenses are best used as a means for plant breeders to gain access to a plant innovation in addition to the breeders' exemption. Research overseas has shown that compulsory license provisions can have significant cascading impacts on the overall level of domestic innovation.[39]

It is not always immediately apparent what that public interest looks like in practice. But New Zealand has other statutes that could help define what public interest is. For example the public interest test in the Commerce Act emphasises "the long-term benefit of New Zealand consumers". The concept that consumers are at the heart of why competition is important has been tested heavily by economists, lawyers and the business community. It is interesting because New Zealand's definition of public interest is different to those applied elsewhere in the World. It takes New Zealand's unique position as a small, island nation with an open economy into account.

Some of New Zealand's largest and most complex plant-based industries (dairy, fruit) are underpinned by PVR rights and simultaneously operate under provisions in the Commerce Act or similar legislation to prevent the abuse of market power. These industries have changed markedly from what they were like when the legislation first placed the power to determine license conditions in the Commissioner.

The public interest test from the Commerce Act

The purpose of the Commerce Act is to "promote competition in markets for the long-term benefit of New Zealand consumers".

To help understand this test, it is useful to understand two key terms.
The first is "competition". This really refers to the way in which businesses make themselves stand out from others. So, businesses might compete on price (by

[39] For example, Moser & Voena (2009) found evidence that compulsory licensing increased domestic invention in the United States by at least 20%.

trying to be the cheapest) or quality (by trying to be the best), or on convenience (by trying to be where you are when you need their product).

The other is "market". We all know what a market is – a place you go to buy things. However, the Commerce Act uses this term in a special way, and its definition can be quite complex. Put simply, market refers to all of the businesses supplying the same sort of thing, and all the people who buy those things. There might be a specific market for, say, roses– the demand is created by local gardeners, and met by breeders, growers, and garden centres. Often, there are debates about who is included or not included in a particular market.

The Commerce Act definition outlined in the box above is helpful because it helps to define priorities for public interest – the priority is consumers. If the compulsory license only helps a New Zealand producer, then the license may not be justified in the public interest. For example, in some cases, protecting a plant variety will only benefit the licensee. In that case, the beneficiary of the compulsory license could possibly be described as a vested interest rather than the 'public'. Even if there were more than one applicant[40], the set of beneficiaries may be so narrow as not to qualify as 'public interest' and therefore may not be justified for a compulsory license. Yet if the license has a clear link back to New Zealand consumer interests, the compulsory licence is more likely to be justified in the public interest. This approach is consistent with industry regulation for say, the kiwifruit industry, which is designed around protecting the interests of New Zealand consumers (for example, by excluding sales of New Zealand kiwifruit, in New Zealand, from the kiwifruit regulations).

Furthermore, the Commerce Act definition (and associated legal precedent) helps to articulate the role of innovation in achieving the public interest. Put succinctly, the "in the long term interests of consumers" aspect of the test is aimed at capturing what happens over the long term, once any secondary effects on innovation and investment in the system are taken into account in the short and medium-term. This is significant because the body of law and evidence that is starting to build around Commerce Act proceedings commonly takes 'chilling effects' (or opposite, encouraging effects) on innovation or investment into account. These effects are difficult to articulate in a broad paper like this that covers all sectors of the plant-based economy. But suffice to say, any competition case that considers say the kiwifruit industry or the dairy industry will contain this type of analysis, and this can create guidance for how a Commissioner might start to weigh up the trade-offs in a compulsory licensing decision.

9.2 Compulsory licenses impose costs and uncertainty

Compulsory licensing imposes costs on a PVR holder. When a compulsory license is granted (and even when there is just a possibility that someone might apply for a compulsory license) the expected returns from a PVR grant fall. The extent to which expected returns will fall varies; in some cases, the terms of a compulsory license will be so wide as to reduce a PVR owner's ability to generate any

[40] The PVR guidance material online contains the comment that an applicant with support from an external party will be more highly regarded than one from an individual applicant.

future return from the PVR. In some cases the terms will be narrow and the PVR owner will not be affected much. In other cases, the owner might have had little expectation of generating a return from the PVR so allowing someone a compulsory license would have very little impact.

PVRs are valuable because they provide certainty for investments in plant breeding. If there was a lot of uncertainty around how compulsory licenses might be used and the costs of the license to the PVR owner, then one might expect a 'chilling effect' on innovation. In some cases, the owners of PVR rights have invested substantially in developing a new variety that is protected by that PVR. These owners would be very concerned about the threat of compulsory licensing, and would not react well to uncertainty around how compulsory license provisions might be used to gain access to their knowledge. In other cases, the owners of the PVR have obtained it without much investment at all. These owners would be less concerned about compulsory licensing and may not worry too much about what might happen if someone applied for a compulsory license relating to their plant variety right.

It is difficult to observe how the test works in practice; since the introduction of plant variety rights in New Zealand, only two compulsory licenses have been granted.[41] Five applications have been made for compulsory licenses in recent years, all by the same company, relating to PVRs over hop varieties. These applications were subsequently withdrawn following a confidential settlement between the application and the PVR owner. Because of this, no compulsory licences were issued and the Commissioner was not required to make a decision.

9.3 Submissions about compulsory licensing

Without any precedent of procedures or how royalties will be calculated to compensation PVR owners, the industry participants we spoke to highlighted considerable concern and uncertainty about whether royalties will be calculated appropriately to compensate the owner for their loss. The current compulsory licence regime is perceived by breeders to be, at best, unsophisticated and lacking clarity, and at worst, a serious deterrent to innovation and investment in new plant varieties.

A consistent collection of concerns were expressed in the submissions to MBIE on the Issues Paper, and again in our interviews. These include:

- There is a lack of legal precedent to refer to, or other guidance about how the provisions might apply in practice. There is certainly a strong sense of urgency that, the boundaries for the Commissioner's decision need to be clearer. At the moment there is little clarity, for example, on how the Commissioner would to consider as 'reasonable' and in the 'public interest'.
- The criteria for granting a compulsory license is not consistent with modern legislation, which has moved on from the test of "reasonable public access" for compulsory licenses to a criterion of "[significant] public interest".
- The initial period in which no licenses can be granted (three years) is too short for commercialisation purposes, leaving little time for the PVR owner to produce reasonable quantities of propagating material or demonstrate a history of behaviour. So even if there

[41] These were granted in 1985 for two varieties of feijoa, "Gemini' and 'Apollo'.

was a 'necessity' test, this short period would make demonstrating 'necessity' for the compulsory license impossible.

- The threshold requirement is too low. For example, the application fee of $600 + GST is low and heavily skews the balance of convenience in applying for a compulsory licence in the applicants favour.
- The application process does not require the application to submit how the applicant's capacity to utilise the rights to be conferred under the compulsory license.
- Section 21(3) in the PVR Act prevents the Commissioner, in their decision making, from taking into account availability of reproductive material where there is a condition that all or any of the produce from that variety must be sold or offered to the PVR owner. This may make the Commissioner's licensing decision difficult (e.g. about what terms would best further the long term benefit of consumers).
- Some are advocating for the procedure to consider an application for a compulsory license and for the terms and conditions of the license to be prescribed, instead of left as subjective standards ("reasonable").[42]

Growers told us that this uncertainty may now be having perverse effects on innovation and investment in new plant varieties. And if it hasn't yet, they say there is considerable risk that it will. When pressed whether they would prefer certain provisions or flexible provisions, most erred toward certainty (and international alignment, where possible).

So New Zealand breeders and growers have told us they do not like the uncertainty about the protection of their rights. They have told us that this uncertainty has potential to deter some investment in new varieties (however, we were not given any specific examples of where this was the case). Looking at the evidence, there are so few compulsory license applications that it is difficult to see why PVR holders are worried. There is a theoretical possibility of misuse of the compulsory licensing regime by allowing spurious or even strategic applications, but spurious or strategic applications are not happening in reality. We accept that a lack of specific decision rules and procedural rules might add to uncertainty, but we did not see evidence of a lack of investment or of a 'chilling effect' from that uncertainty.

Suggestions from breeders that the current settings associated with compulsory licensing are undermining incentives to invest in new varieties are concerning, but it is worthwhile pointing out that they have a vested interest in getting compulsory license provisions toned down or removed. It is certainly not the intention of the provision. Rather, the compulsory license provision in the PVR Act is intended to safeguard the continuation of innovation in New Zealand, while allowing access to the PVR (with appropriate compensation) if that access is necessary and in the public interest.

[42] By comparison, in determining authorisation of a compulsory license in the EU, situations which may constitute public interest are explicitly stated and include: (a) the protection of life or health of humans, animals or plants; (b) the needs to supply the market with material offering specific features; and (c) the need to maintain the incentive for continued breeding of improved varieties. These authorisation terms are not necessarily the most optimal set (we take issue with the second term, for example). The authors have included them to highlight a point made by growers, that the absence of any resembling definition (even in guidance) creates uncertainty.

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Appendix A: Picturing innovation systems

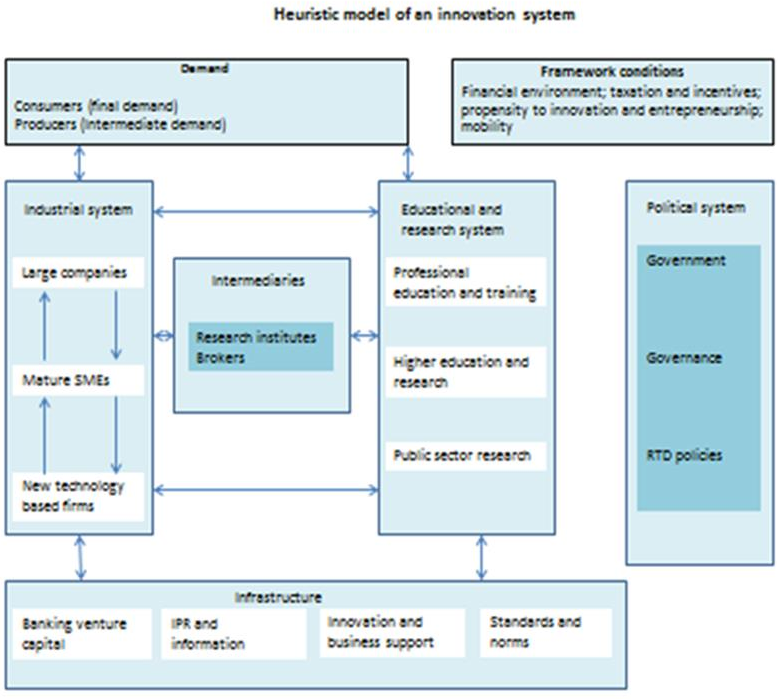
The brief for this report was to ask, what does the innovation system look like?

As part of the research for this report the authors considered two approaches to picturing innovation systems. Both were subsequently rejected for a simplified, tabular representation. However the approaches may have use for MBIE, which is why we have summarised them here.

Approach 1 – Static model

For example, Kuhlmann and Arnold (2002) prepared this simple, static framework. It shows the political system as largely exogenous. The education and research system and the industrial system are shown as responding to consumer and producer demand; the infrastructure (which includes intellectual property rights) is show as responding to the industrial system and the research system. Research institutes (and JVs) are intermediaries.

Kuhlmann and Arnold innovation model, 2002



Approach 2 – a systems dynamics model

A technological innovation system can be analysed by looking at how the different functions it is supposed to carry out are fulfilled (Hekkert et al. 2007; Bergek et al. 2008a,b; Hekkert and Negro 2009;

Suurs and Hekkert 2009). Abstracting from differences in wording, the following categories of an innovation system's functions can be distinguished[43]:

- knowledge generation (F1),
- knowledge diffusion (F2) through exchanging information in networks, but also along the value chain (including supplier-user interaction),
- guidance of search (F3), that is directing R&D and search for new solutions with respect to technology and market,
- entrepreneurial experimentation (F4), leading to diversity and a variety of solutions in order to allow for a sufficiently large stock of technologies enabling the selection process to result in a dominant design.
- facilitation of market formation (F5), which enables learning in the market and scale effects.
- legitimization (F6) of a new technology, which is closely connected with recognising a growth potential for the technology and the ability to counteract political resistance and to push for political support.
- resource mobilisation (F7), which is especially important for new technologies associated with a higher risk of failure.

PVRs support each of these functions directly or indirectly; we argue in the main text that PVRs work in combination with other strategies like contracting or vertical integration to provide protections against appropriability.

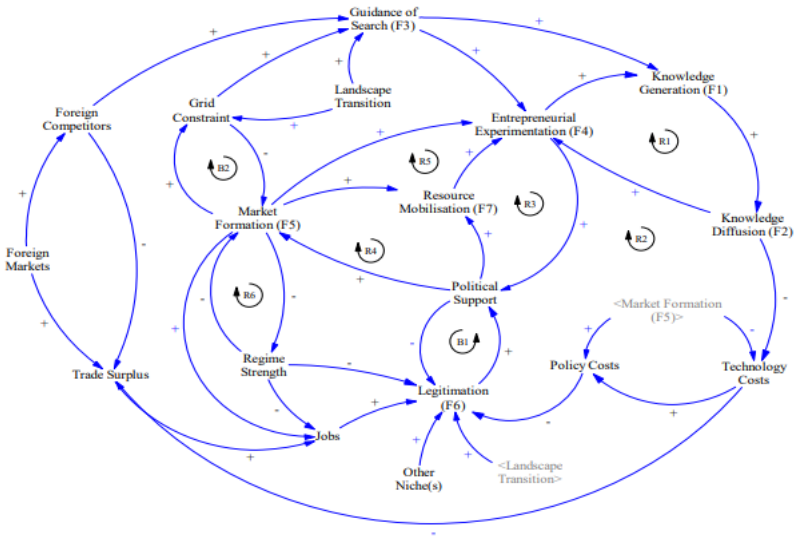
These functions have internal dynamics too, that is, internal feedback loops. Bergek et al. (2008c) point out that the mechanisms and interactions of the actors of an innovation system, and the feedback loops between the different functions need to be taken into account to properly understand the innovation process. These feedback mechanisms can induce an increase in innovations but also block further development (Bergek et al. 2008b; Hekkert and Negro 2009). It is within these dynamic relationships that the development of an innovation system takes place.

One can model systems dynamics for innovation systems. These structures can be further processed into causal-loop diagrams for computer-based simulations. This was beyond our brief for this work but potentially interesting for future research.[44] An example of a feedback loop model for wind energy is presented below.

[43] This summary was obtained from Fraunhofer <https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccp/innovation-systems-policy-analysis/2016/discussionpaper_50_2016.pdf>

[44] The VENSIM software, for example, provides a flexible and simple platform for building simulation models (Ventana Systems, 2003).

Figure 8: Causal-loop- diagram of wind energy innovation system in Germany



Source: Fraunhofer ISI

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